UNIVERSIDADE FEDERAL DE SANTA MARIA
CENTRO DE CIÊNCIAS RURAIS
PROGRAMA DE PÓS-GRADUAÇÃO EM ZOOTECNIA

Bruno Castro Kuinchtner

MANEJO DE PASTAGEM NATURAL EM PASTOREIO ROTATIVO UTILIZANDO DUAS SOMA TÉRMICA COMO INTERVALO DE DESCANSO

Santa Maria, RS
2016

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Tese apresentada ao Curso de Doutorado do Programa de Pós-Graduação em Zootecnia, Área de Concentração em Produção Animal, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para obtenção do grau de **Doutor em Zootecnia**

Orientador: Prof. Dr. Fernando Luiz Ferreira de Quadros

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Ficha catalográfica elaborada através do Programa de Geração Automática
da Biblioteca Central da UFSM, com os dados fornecidos pelo(a) autor(a).

Castro Kuinchtner, Bruno
MANEJO DE PASTAGEM NATURAL EM PASTOREIO ROTATIVO UTILIZANDO DUAS SOMA TÉRMICAS COMO INTERVALO DE DESCANSO / Bruno Castro Kuinchtner.-2016.
80 p.; 30cm

Orientador: Fernando Luiz Ferreira de Quadros
Tese (doutorado) - Universidade Federal de Santa Maria, Centro de Ciências Rurais, Programa de Pós-Graduação em Zootecnia, RS, 2016

1. Pastagem Natural 2. Manejo 3. Pastoreio Rotativo 4. Bioma pampa 5. Graus-dia I. Ferreira de Quadros, Fernando Luiz II. Título.

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Santa Maria, RS
2016

DEDICATÓRIA

A minha família, meu pai Adelir, minha mãe Júlia. Pelo esforço, dedicação, carinho, pela educação recebida. Aos meus irmãos que sempre estiveram ao meu lado, incentivando-me.

AGRADECIMENTOS

Ao fim delega-se o dia de escrever os agradecimentos, forte indicador de que a Tese está finalmente sendo concluída, assim, encerra-se uma etapa. Neste momento, olhamos para trás para recordar as experiências, as pessoas, que tornaram possível, ajudaram e apoiaram este “projeto”.

Com certeza a finalização deste trabalho deve-se, principalmente, pelo auxílio, dedicação, paciência, compreensão de todos que estiveram de alguma maneira envolvidos para a conclusão deste trabalho, em especial agradeço:

- ao meu orientador, professor, Fernando Luiz Ferreira de Quadros, pela oportunidade concedida, paciência, ensinamentos, exemplo de profissional e de ser humano, obrigado pela convivência;

- aos colegas, pelas inúmeras colaborações, dedicação, companheirismo, momentos alegres, risadas, pela amizade;

- à Universidade Federal de Santa Maria, pela oportunidade de desenvolver e concluir este trabalho;

- aos professores e funcionários do Programa de pós-graduação em Zootecnia por contribuírem na realização desta conquista;

- às professoras, Marta Gomes da Rocha e Luciana Pötter por todas as contribuições no desenvolvimento deste trabalho;

- à Suelem Lima da Silva, minha namorada, pela compreensão, carinho e apoio constante.

- aos bolsistas e estagiários (Pedro Casanova, João Bento Pereira, Augusto Fernandes, Fernanda Taschetto, Denise Steinhorst, Fernando Ongaratto, Felipe Xavier, Franciéle Guzatto, Luciana Marin, Bernardo Bopp, Simone Callai, Frederico de Azevedo, Giovana Giaretton, parceiros (as) incansáveis, este trabalho é fruto da colaboração de cada um de vocês;

- ao professor Luciano Adrián González, pela recepção, paciência, confiança, grato pela oportunidade;

- à CAPES pelo auxílio financeiro durante a realização deste trabalho e pela concessão da bolsa PDSE.

- à todos que de alguma maneira contribuíram para a conclusão deste trabalho.

Com carinho, meu muito obrigado!

RESUMO

MANEJO DE PASTAGEM NATURAL EM PASTOREIO ROTATIVO UTILIZANDO DUAS SOMA TÉRMICA COMO INTERVALO DE DESCANSO

AUTOR: Bruno Castro Kuinchtner
ORIENTADOR: Fernando Luiz Ferreira de Quadros

O objetivo deste trabalho foi avaliar a utilização de duas somas térmica, expressa em graus-dia, como intervalo de descanso entre pastejos em pastagem natural. Durante Abril de 2013 a Abril de 2014, foi avaliado o efeito do manejo do pasto, na vegetação e suas consequências no desempenho, comportamento ingestivo e no consumo de matéria seca de bezerras de corte manejadas em pastoreio rotativo. O delineamento experimental foi o de blocos completamente casualizados, com dois tratamentos e três repetições de área, as repetições foram subdivididas em sete e oitos piquetes, para cada um dos tratamentos. O experimento foi realizado em área pertencente à Universidade de Santa Maria, localizada região fisiográfica da Depressão Central do Rio Grande do Sul, Brasil. Os tratamentos foram duas somas térmicas: 375 e 750 graus-dias (GD), que determinaram os intervalos entre os pastoreios, o tratamento de 375 GD, foi definido pela duração da expansão foliar de espécies de crescimento prostrado (*Axonopus affinis* e *Paspalum notatum)* e o tratamento de 750 GD, pela duração da expansão foliar de espécies cespitosas (*Aristida laevis* e *Saccharum angustifolius)*. A área experimental possuía 23 ha e foi dividida em seis unidades experimentais, que abrigaram os dois tratamentos e as três repetições. Trinta bezerras de corte da raça Red Angus foram utilizadas como animais testers e número variável de reguladoras da mesma categoria e raça. As bezerras possuíam idade média inicial de 7 meses e peso médio inicial de 150 ± 5 kg. Durante a estação fria as bezerras receberam farelo de arroz integral corrigido com 4% de calcário calcítico, como suplemento a uma taxa de 1,0% do peso vivo diariamente às 14 horas. Em ambos os tratamentos a massa de forragem, o desempenho, o comportamento ingestivo e o consumo de matéria seca não diferiram ($P<0.05$). A soma térmica em graus-dia baseada na característica morfogênica, taxa de elongação foliar como intervalo de descanso entre pastejos pode ser uma ferramenta de manejo para melhorar a produção animal por área, a qualidade da forragem, além de possibilitar elevada taxa de lotação.

Palavras-chave: Bioma Pampa. Graus-dia. Produção Animal. Consumo Ingestivo.

ABSTRACT

NATURAL GRASSLAND MANAGEMENT ON ROTATIONAL GRAZING UNDER TWO THERMAL SUMS AS REST INTERVALS

AUTHOR: Bruno Castro Kuinchtner
ADVISOR: Fernando Luiz Ferreira de Quadros

The objective of this study was to evaluate the use of a thermal sum rest period on natural grassland as a grazing management, these grazing intervals has been used since 2009. During April 2013 to April 2014, we evaluated the effect of this grazing management on vegetation and its consequences in the performance, grazing behavior and dry matter intake of beef heifers on Pampa biome (southern Brazil). A complete randomized block design experiment with two treatments and three replications was conducted with Angus heifers. The treatments were two thermal sums: 375 and 750 degrees-days (DD) determined by the intervals between rotational grazing periods, the 375 DD treatment favors prostrate species (*Axonopus affinis* and *Paspalum notatum)* and the 750 DD treatment favors tussock species (*Aristida laevis* and *Saccharum angustifolius)*. The 23 ha experimental area was divided into six experimental units, which housed two treatments and three replications. The experiment was conducted with beef cattle heifers *testers* with average age of 7 months old and initial weight of 150.5 ± 5 kg. Every heifers received whole rice bran supplement at a rate of 1.0% of body weight per day during cool season (April to September) and had free access to mineral supplement. Treatments had no differences on vegetation, average daily weight, dry matter intake, grazing behavior variables and beef production. Thermal sum rest intervals could be a valuable grazing management tool to improved animal production per area and forage quality, besides high animal stocking rate.

Keywords: Livestock, Pampa biome. Leaf Elongation Duration. Beef Cattle.

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LISTA DE ABREVIATURAS E SÍMBOLOS

TRAT	Tratamento
REP	Repetição
PER	Período
OFLF	Oferta de lâminas foliares
CA	Carga animal
GMD	Ganho médio diário
PCI	Peso corporal inicial
PCF	Peso corporal final
GA	Ganho de peso por área
LF	Lâmina foliar
MM	Material morto
MFE	Massa de forragem de entrada
MFS	Massa de forragem de saída
MLF	Massa de lâmina foliar

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APRESENTAÇÃO

INTRODUÇÃO

O ecossistema pastagens naturais corresponde a 31 – 48% da superfície da terra (Gauthier et al., 2003). As pastagens naturais estão declinando em escala global, atualmente o sistema econômico mundial direciona o uso das áreas naturais em “commodity” agrícolas (Haddock & Good, 2012). Muitas das pastagens naturais de elevada produtividade tem sido convertidas para outros usos, sendo um dos mais produtivos e diversos ecossistema terrestre, as pastagens naturais também são um dos mais ameaçados no mundo (Suttie et al.,2005).

As pastagens naturais fornecem diversos alimentos, bens e serviços, são o meio de subsistência e economia de muitos, incluindo mais de um bilhão de pessoas de baixa renda (Haddock & Good, 2012). No manejo de ambientes campestres, têm de ponderar além da produção de alimentos, a prestação de serviços ecossistêmicos gerados (por exemplo, ciclagem de água, conservação da biodiversidade, a conservação do solo, habitat dos animais selvagens, a polinização, o sequestro de carbono, etc.).

O declínio das áreas campestres também é devido à invasão de plantas exóticas e ao sobrepastoreio. Um adequado manejo do pastoreio permite uma perturbação natural e desejável que é compatível com a conservação das pastagens naturais. Portanto, o continuo e adequado manejo do pasto por produtores de gado é uma maneira de melhorar os serviços dos ecossistemas campestres e pode ser a melhor maneira de conservar os restantes das pastagens naturais.

Desenvolver ferramentas de manejo que possibilitem elevar a produção animal e conservação dos serviços ecossistêmicos prestados pelas pastagens naturais é um desafio constante aos manejadores destes complexos ambientes campestres. Portanto, é necessário desenvolver alternativas de manejo que permitam um uso mais adequado e sustentável dos recursos naturais, visando minimizar impactos de um manejo não adequado e conscientizar sobre a importância da conservação das pastagens naturais para aquém da produção animal.

PROPOSIÇÃO

As pastagens naturais estão declinando em escala global, ou seja, estão sendo convertidas em outros usos, regido principalmente pelas “commodity” agrícolas. Uma alternativa para desacelerar as perdas dos ecossistemas campestres é melhorar a sua eficiência de utilização, ou seja, a transformação da biomassa vegetal em produto animal sem comprometer a resiliência do recurso natural. Portanto, é necessário pesquisar alternativas de manejo que possibilitem aumentar de maneira sustentável os índices de produtividade.

Nosso objetivo foi avaliar duas somas térmicas expressa em graus-dia como ferramenta de manejo para pastagens naturais baseado em caraterísticas intrínsecas das principais espécies de gramíneas, assim, melhorar o desempenho animal sem descuidar da conservação do recurso natural.

MATERIAL E MÉTODOS

1. Local, data, tratamentos e área experimental

O experimento foi conduzido de abril de 2013 a abril de 2014 em uma área de pastagem natural pertencente à Universidade Federal de Santa Maria, situada na região fisiográfica Depressão Central do Rio Grande do Sul, nas coordenadas $29^0$43’29,97”S $53^0$45’36,91”W. A altitude a nível do mar é de 95 m e o clima da região é subtropical úmido (Cfa) conforme a classificação de Köppen. Na área experimental predominam dois tipos de solos: Planossolo Háplico Eutrófico nas áreas de baixada e Argissolo Vermelho Distrófico nas áreas de topo e encosta (Streck et al., 2008). As médias das temperaturas mínimas e máximas para o período avaliado foram de $17,1^0$C e $22,7^0$C, a precipitação média do período avaliado foi de 130,6 mm mensal, sendo o mês de outubro o de menor precipitação, com 53,6 mm e o mês de novembro o mais chuvoso com 294,9 mm.

Os tratamentos avaliados foram duas somas térmicas: 375 e 750 graus-dia (GD), determinando os intervalos entre pastoreios em método rotativo. O primeiro intervalo considera a soma térmica necessária para a elongação de duas folhas e meia da espécie *Axonopus affinis* e *Paspalum notatum,* gramíneas prostradas, competidoras por recursos, pertencente aos grupos A e B (Quadros et al.,2006), com filocrono de 164 GD (Eggers et al., 2004) e o intervalo de 750 GD representa a duração de elongação de duas folhas das espécies cespitosas dos grupos C e D (Quadros et al.,2006), tais como: *Aristida laevis* e *Saccharum angustifolius*, com filocrono de 333 GD (Machado et al., 2013).

A área experimental possuía 23 ha, dividida em seis unidades experimentais, os quais alocaram dois tratamentos e três repetições de área. Para o tratamento 375 GD, as repetições foram subdivididas em sete piquetes para a rotação dos animais e no tratamento 750 GD as áreas foram divididas em oito piquetes, totalizando 45 piquetes de 0,5 ha cada. Todos os piquetes eram providos de bebedouros automatizados.

2. Animais experimentais, suplementos e manejo do pastoreio

Trinta bezerras de corte da raça Red Angus foram utilizadas como *testers*, com idade média inicial de 7 meses e peso médio no início do experimento de 150 ± 5 kg. Animais da mesma raça e categoria foram utilizados para o ajuste da lotação. Os animais foram distribuídos em seis grupos de maneira que o peso total de cada grupo ficasse semelhante, cada grupo possuía cinco animais. Durante a estação fria (abril a setembro de 2013) as bezerras receberam farelo de arroz integral corregido com 4% de calcário calcítico, como suplemento a uma taxa de 1,0% do peso vivo diariamente às 14 horas. O controle sanitário dos animais foi realizado de maneira preventiva ou quando necessário.

O tempo de ocupação de cada piquete foi em função dos intervalos entre pastoreios, conforme a fórmula abaixo.

$$\text{Ocupação (dias)} = \frac{\text{Intervalo (GD)}}{N^0 \text{ piquetes -1(piquete em pastejo)}}$$

Ambos os tratamentos foram manejados com carga animal fixa durante a estação fria (abril a setembro) e oferta variável de biomassa. Durante a estação quente (setembro a abril) a carga animal foi variável (Mott & Lucas, 1952), a carga animal foi ajustada com base nos valores de lâminas foliares verdes, de forma a serem removidos 70 % da massa de lâminas foliares, mantendo um resíduo de 1500 kg MS/ha, considerou-se um desaparecimento de forragem de 4,5% do peso corporal (PC) (Heringer & Carvalho, 2002). Foi selecionado um piquete por repetição que representasse a amplitude de biomassas para ser o piquete representativo. Neste piquete foram realizadas todas as avaliações referentes à forragem.

3. Avaliações na vegetação e nos animais

A massa de forragem (MF) foi determinada através da técnica de estimativa visual de comparação a padrões, calibrada com dupla amostragem (Haydock & Shaw, 1975), com 20 estimativas visuais e seis cortes rente ao solo, utilizando um quadrado de 0,25m^2. Da biomassa cortada, uma subamostra foi retirada para a quantificação dos componentes estruturais e botânicos em: folhas verdes, colmo e bainhas (gramíneas), material morto e outras (espécies não pertencentes a família Poaceae). Após a separação, os componentes eram levados à estufa de ventilação forçada de ar até peso constante e posteriormente pesados para a determinação do percentual de matéria seca do pasto e dos componentes estruturais. Os valores são apresentados em kg de matéria seca (MS) por unidade de área (kg MS. ha^{-1}).

4. Avaliações de comportamento ingestivo e consumo de matéria seca

As avaliações de comportamento ingestivo, foram realizadas em sete ocasiões, quando os animais foram identificados com tinta acrílica na região do costilhar para melhor visualização. As observações de comportamento ocorreram no segundo ou terceiro dia de ocupação dos piquetes. As atividades comportamentais de pastejo, ruminação, ócio e outras atividades foram observadas visualmente por 18 horas ininterruptas das 7 às 23:59 hs com intervalo de 10 minutos entre avaliações.

Para o tempo de pastejo foram considerados os tempos despendidos na atividade de pastejo propriamente dita, assim como o tempo gasto na procura por alimento, incluindo os curtos espaços de tempo utilizados no deslocamento para seleção da dieta (Hodgson, 1982). O tempo de ruminação foi considerado quando o animal manifestasse movimentos mandibulares sem que estivesse em processo de pastejo. O tempo de ócio foi considerado o período em que os animais se mantinham em descanso, e em atividades diversas do pastejo ou ruminação.

Foi registrado o tempo despendido pelo animal para a realização de vinte bocados (taxa de bocados), para visitar dez estações alimentares e o número de passos efetuados. Uma estação alimentar é definida como um semicírculo que possa ser alcançado sem que haja movimento das patas dianteiras (Ruyle & Dwyer, 1985).

O valor nutritivo do pasto foi determinado em amostras de simulação de pastejo (Euclides et al., 1992). A forragem coletada foi separada manualmente nos componentes estruturais descritos acima, posteriormente alocados em estufa de circulação forçada de ar a 65 ^{0}C até peso constante, somente as lâminas foliares foram trituradas em moinho do tipo *Willey* com peneira de 2 mm. A fibra em detergente neutro (FDN) e a fibra em detergente ácido (FDA) foram determinadas conforme Van Soest (1967), a degradabilidade *in situ* da matéria orgânica (DISMO) foi realizada de acordo com (Orskov & McDonald, 1979), para esta determinação as amostras foram trituradas com peneira de 1 mm. A matéria seca foi determinada à 105ºC, a matéria orgânica (MO) e o nitrogênio total foram mensurados seguindo os procedimentos da (AOAC, 1990).

O consumo de matéria seca de forragem foi estimado utilizando duas bezerras em cada repetição, sendo utilizado o óxido de cromo (Cr_2O_3) como marcador externo, fornecido uma vez ao dia com 200 g de farelo de arroz integral. Na mesma ocasião marcadores de polietileno de cores distintas (resíduos de plásticos rígidos) foram fornecidos para cada animal. O marcador de polietileno (MP) possuía tamanhos entre 0,5 a 1,5 cm de comprimento e 0,5 a 1,0 cm de largura. Cada animal recebeu uma cor do MP com aproximadamente 20 gramas diariamente, através do MP foi possível identificar as fezes do animal na pastagem, dispensando a coleta fecal através do reto.

O fornecimento do indicador externo seguiu o seguinte protocolo: os animais receberam durante dez dias, aproximadamente 5 g de óxido de cromo (8 cápsulas de queratina) diariamente, nos últimos três dias foram realizadas as coletas de fezes. Para as coletas efetuaram-se duas coletas diárias “varreduras” nos piquetes, uma em cada turno do dia. As fezes que possuíam o MP foram coletadas e armazenadas em recipientes de alumínio (marmitex) e alocadas em estufa de ventilação forçada de ar a 65^{0}C até que as amostras estivessem totalmente secas. As amostras de fezes secas foram maceradas e trituradas em moinho tipo *Willey* com peneira de 1 mm para determinação da matéria seca e teor de cromo.

O teor de cromo nas fezes foi determinado por amostras compostas dos turnos e dias de coleta, foram retirados 3 g de cada amostra coletada para formar a amostra composta. O teor de cromo nas fezes foi determinado através de espectrofotômetro de absorção atômica, conforme metodologia descrita por Williams et al. (1962). A produção fecal (PF) foi obtida da seguinte maneira: cromo fornecido (g/dia) dividido pela concentração de cromo nas fezes (g/ kg MS), dividido pela taxa de recuperação do cromo. O consumo de matéria seca do pasto foi mensurado através da fórmula: (PF – (S* (1-(DISMS do S/100))))/ (1-(DISMS F)/100), onde: PF é a produção fecal, S é a quantidade de suplemento consumido diariamente, a DISMS do S é a degradabilidade *in situ* da matéria seca do suplemento e a DISMS F é a degradabilidade *in situ* da matéria seca da forragem.

5. Delineamento experimental

O delineamento experimental foi o de blocos casualizados, com dois tratamentos e três repetições de área. Os dados foram submetidos ao teste de normalidade pelo procedimento PROC UNIVARIATE, à análise de variância através do PROC MIXED e PROC GLIMMIX e teste F em nível de 5% de significância, utilizando o programa estatístico SAS 9.4.

CAPÍTULO I

Use of thermal sum (degrees-days) rest period as a grazing management tool: effects on animal performance and forage production

Capítulo baseado nas normas para submissão de artigo científico da revista Animal Journal

Use of thermal sum (degrees-days) rest period as a grazing management tool: effects on animal performance and forage production

Authors

Abstract: The objective of this study was to evaluate the use of a thermal sum rest period on natural grassland as a grazing management, these grazing intervals has been used since 2009. During April 2013 to April 2014, we evaluated the effect of this grazing management on vegetation and its consequences in the performance of beef heifers on Pampa biome (southern Brazil). A complete randomized block design experiment with two treatments and three replications was conducted with Angus heifers. The treatments were two thermal sums calculated at 375 and 750 degrees-days (DD) to determine the intervals between grazing periods in a rotational grazing system. The experiment was conducted with beef cattle heifers *testers* with average age of 7 months old and initial weight of 150.5 ± 5 kg. Every heifers received whole rice bran supplement at a rate of 1.0% of body weight per day during cool season (April to September) and had free access to mineral supplement. Treatments had no differences on forage production, average daily weight gain and beef production. Thermal sum rest intervals could be a valuable grazing management tool to improved animal production per area and forage quality, besides high animal stocking rate.

Keywords: livestock, Pampa biome, leaf elongation duration, beef cattle

Implications

Grasslands has a multifunctional role to Humanity, with unique fauna and flora, besides being the main source feed to herbivorous. However, it is considered as a “poor” ecosystem, being converted too other uses such as agriculture and forestry cultivation. The development of easy methodologies that allow to increase beef production from natural grasslands and at the same time conserve its vegetation, has been increasingly demanded, due to population increase and world pressure by clean food production systems. The implications of this trial is to search a management tool able to improve beef production, without compromising natural resource sustainability**.**

Introduction

South America natural grasslands include all of Uruguay, northeast Argentina, south Brazil and part of the Paraguay. In Brazil, natural grasslands are located in the southern region and consist of two biomes. According to the national classification (IBGE, 2004), the grasslands situated in the northeast region of Rio Grande do Sul, Santa Catarina and Paraná states belong to Mata Atlântica Biome and the grasslands situated in the southern part of Rio Grande do Sul (RS) state are belonging to Pampa Biome, present only on this state of Brazil.

Pampa Biome represents 2.07% (176.496 Km^2) of Brazilian territory (IBGE, 2004) and, currently, still remain 23% (41.054,61 Km^2) of its natural vegetation, mainly grasslands, without anthropic modification (Hasenack *et al*., 2010) . Pampa biome have high species diversity, according to Boldrini *et al.* (2009), grasslands diversity of RS is in the order of 2.200 species, what can be considered a high number, if compared with North-American grasslands. Currently, south Brazil grasslands are being converted to other uses, mostly agricultural and forestry cultivation and, besides of the species losses, cultural habits are been also lost, mostly because this culture was based on a tradition of beef cattle livestock production, which started at the beginning of Brazilian colonization at Rio Grande do Sul (Nabinger *et al.* 2000).

Meat and milk production to meet increasing global demand will require increased herd productivity within constraints for sustainability of grassland ecosystems and continuing provision of livelihoods and services (Boval and Dixon, 2012), therefore, is important to define appropriate management strategies to grazing systems that are based in natural resources, as the native grasslands (Hodgson and Da Silva, 2000). However, grasslands with high species biodiversity, as observed in the Pampa biome, renders grazing management difficult and becomes almost impossible to prioritize only one aspect (e.g. animal, plant and soil) making necessary a holistic system approach.

To facilitate natural grassland management evaluation for optimal animal production and conservation, Cruz (2010) simplified the grass species diversity using functional groups with similar leaf area index and dry matter content. Similarly, Quadros *et al.* (2011) suggested as a grazing management tool the use these functional groups, considering two groups, one with species of resources capture (A and B groups) and another with species that conserved the resources (C and D groups).

The species from A/B groups have a low phyllochron, (Eggers *et al*., 2004; Machado *et al.,* 2013), in others words, need a lesser time period for the emergence of two consecutive leaves. Otherwise, account with the species of the C/D groups that have a higher phyllochron, a long time (thermal sum) is required by these species (Machado *et al.,* 2013). Phyllochron is correlated to leaf elongation duration (LED) which is the temperature required for a leaf reach its maximum length (Skinner and Nelson, 1995).

Both of these characteristics are measured through a thermal sum expressed in degree-days (DD), being defined as the sum across days of the average between maximum and minimum daily temperatures (Ometto, 1981). Therefore, the time required for two consecutive leaves to emerge and for a leaf to reach its maximum length decreases with increasing ambient temperature because the thermal sum will be reached faster, in a similar way to growth rate of the plants.

The use of thermal sum (DD) in near real-time as a grazing management tool (i.e. calculating DD according to ambient temperature on a day per day basis) would allow accounting for the effects of actual environmental conditions and specific characteristics of plant functional groups. The thermal sum is a simple tool to be measured on farm and has the potential to improve grazing management as it determines permanence time and length of grazing intervals for each specific grazing system.

The thermal sum as an alternative management tool in rotational stocking rate could allow adjusting the relationship between dead and green herbage mass and consequently an optimal cost/benefit ratio compared to others alternative grazing systems (Quadros *et al.,* 2011). Therefore, degrees days could help increasing profitability and competitiveness of natural resources while preserving the grassland ecosystem in southern Brazil, through the maintenance of productivity and stability soil, plants and animals (Hodgson and Da Silva, 2000).

Our objective was to evaluate two thermal sum as grazing management tool to improve animal performance and biodiversity conservation on Pampa biome.

Material and methods

Period, treatments and experimental area

The experiment was conducted from April 2013 to April 2014 on a natural grassland located at Universidade Federal de Santa Maria.The study site ($29^0$43'29.97" S $53^0$45'36.91" W) is located at Depressão Central region, in Rio Grande do Sul state, Brazil. The climate is subtropical humid (Cfa classification, Köppen), with 95 m sea level. The study site has two soil types: Typic Albaqualfon lowland areas and Rhodic Paleudalf on top and slope areas. During the trial, the mean maximum temperature was 22.7ºC and the mean minimum temperature was 17.1ºC, the mean precipitation was of 130.6 mm per month, November is the wettest month (294.9 mm), and October is the driest (53.6 mm).

Treatments consisted of two different thermal sums, 375 and 750 degree-day (DD), determining the length of the rest intervals of paddocks among grazing events. The 375 DD is the interval necessary for the elongation of 2.5 leaves of *Axonopus affinis* and *Paspalum notatum,* which are prostrate C_4 grasses of the functional groups A and B, with an average phyllochron of 150 DD (Eggers *et al.,* 2004; Machado *et al.,* 2013). The 750 DD represent the time for elongation of 2.2 leaves for tufted grasses from functional groups C and D, as *Aristida laevis* and Saccharum *angustifolius,* with phyllochron of 333 DD (Machado et al., 2013).

The occupation time of each grazing cell was a function of rest time (among the grazing periods) according to the following formula:

$$\textit{Occupation (degree-days)} = \frac{\textit{Interval (DD)}}{\textit{Nro. grazing cells -1 (cell in use)}}$$

Where DD is the treatment DD, 1 is the number of paddocks in use, and *Nro. grazing cells* is either 7 or 8 for the 375 and 750 DD treatments, respectively. For 375 DD, it ranges from 3 to 6 occupation days, with mean of 3.7 and for 750 DD, it ranges from 6 to 11 occupation days, with mean of 6.2 days

Both treatments were managed from April to September 2013 with constant stocking rate and variable herbage allowance and from September to last period with put-and-take technique under rotational grazing. A grazing cell (0.5 ha) was selected in each replicate (representative cell), the variation in biomass and plant species contribution where all the pasture measurements were carried out.

The trial lasted for 377 consecutive days and was divided into thirteen periods: April 25^{th} to May 23^{th}(period 1); May 23^{th} to June 24^{th} (period 2); June 24^{th} to July 25^{th}(period 3); July 25^{th} to August 28^{th}(period 4); August 28^{th} to September 19^{th} (period 5); September 19^{th} to October 17^{th} (period 6); October 17^{th} to November 14^{th} (period 7); November 14^{th} to December 12^{th} (period 8); December 12^{th} to January 9^{th} (period 9); January 9^{th} to February 6^{th} (period 10); February 6^{th} to March 6^{th} (period 11); March 6^{th} to April 3^{th} (period 12) and April 3^{th} to May 1^{th} (period 13).

A completely randomized block design with two treatments and three replicates (6 paddocks) were used. The experimental area had 23 ha divided into six paddocks (experimental units) randomly assigned to the two treatments with three replicates each. In treatment 375 DD, each replicate paddock was subdivided in seven cells whereas in the 750 DD treatment the replicates were divided in eight cells for animal rotation. In total, 45 grazing cells with 0.5 ha each were used and all were provided with fresh water.

Experimental animals, supplements and grazing management

Five beef cattle heifers Angus (*Bos taurus Taurus*) were used as *testers,* with seven-month-old and mean initial body weight of 150.5 ± 5 kg, heifers were blocked by body weight (6 groups with similar body weight), variable number of animals of the same breed were used to adjustment. All animals received daily supplementation from periods 1 to 5, at 2:00 p.m. at a rate of 1.0 % of body weight of whole rice brain (16.3 % of crude protein and 74 % *In situ* rumen degradability from OM).

Both treatments were managed with constant stocking rate and variable herbage allowance during cool season (April to September).From 19 September on, it was used a variable number of “put-and-take” heifers for stocking rate adjustments, with the same age of the test-animals. Stocking rate (SR) was adjusted using the proportion of leaves in the sward, so that the calculated SR could remove 70% of the leaf mass and keep a residual mass of 1500 kg ha^{-1} under rotational grazing.

Sanitary control was made when necessary with pour-on (Fluazuron or Fipronil) or sprinkling shower (Amitraz), and vaccination as required.

Vegetation animal and measurements

The herbage mass (HM; kg of dry matter (DM) per ha) was measured using a direct comparison to standards calibrated with double-sampling technique (Haydock and Shaw, 1975), six samples were clipped at ground level on 50 × 50 cm quadrate and 20 visual estimations were accomplished in the representative cell for each replicate.

Clipped forage was weighted and divided into 2 subsamples, one subsample was used to determine DM content, dried in a forced air oven at 55ºC for at least 72 hours and the another subsample was used to separate structural components. Manual separation of the structural components of the pasture was performed to obtain the percentage of green leaf lamina, pseudo stem (grass species), dead material and plant species other than grass (e.g. Cyperaceae, Asteraceae). Leaves blade allowance (kg DM per 100 kg body weight) was calculated using the mean leaf present in the HM in each period, divided by the number of occupation days and divided by the stocking density, multiplied by 100.

The mean leaf was calculated using the percentage of green leaves material, obtained by the separate component of the herbage mass (pregrazing) in each cell evaluated.

Stocking density (SD), was calculated as the sum of all animals' body weight in an experimental group divided by the cell area. Mean stocking rate (MSR; kg/ha of body weight) was calculated by dividing the number of animals to be grazed by total area grazed (paddock repetition). Beef production gain per area (BP; kg BW/ha) was calculated as number of animals per area multiplied by daily weight gain and number of days per period. The animals were weighed each 28 consecutive days, after a total fasting period of at least 12 hours, average daily weight gain (ADG) calculated, and body condition score (BCS) recorded. The ADG was the difference of body weight between 2 consecutive weights divided by the number of days between measurements.

The herbage intake was measured on four occasions (June21th, September9th, December 11th, April 2th2014; period 2, 5, 8 and 12), using two animals by replicate, with Cr_2O_3 (chromium oxide). The period for adaptation and collection of feces samples comprised 10 consecutive days. Cr_2O_3 capsule was provided together with 0.200 kg of whole rice brain, once a day (Kozloski*,* 2006). On the same occasion to avoid discomfort for the animals in collects days, was also provided a polyethylene external marker (20 g), with different colors for each animal to identify the feces. The polyethylene external marker were made with plastic paper A4 of 0.3 mm thickness, using a manual machine binder (Excentrix) with 4 mm diameter. For ten consecutive days, animals were given 5g of Cr_2O_3, and in the last three days the fecal samples were collected. The Cr_2O_3 supply was started in view of the fecal collection when animals were moving into the representative paddocks. For collections, daily "sweeps" on cell paddocks were performed. If the polyethylene marker was present, samples were collected. The collected samples were dried until constant weight and grinded in 1mm.

Samples of 0.5 g was weighed and incinerated in a muffle at 600ºC for three hours for Cr_2O_3 determination. Afterwards, 5 ml Cr_2O_3 digestion solution was added, according to Czarnocki (1961) and placed in a hot plate at 220ºC. After the change in sample color (green to yellow), the content was filtered and transferred to a 100 ml volumetric flask, completing the volume with distilled water to measure the Cr_2O_3 concentration by atomic absorption spectrophotometry. The standard curve was prepared with 100 mg Cr_2O_3. Fecal production (FP) was estimated as follows: FP = supplied Cr_2O_3 (g/day) / feces [Cr_2] (g/kg DM). Then, the intake estimation was calculated as follows: Intake (g/day) = FP (g/day) / (1-degradability). *In situ* rumen degradability of herbage OM (ISRDOD) apparently consumed by animals was determined according to (Orskov and Mcdonald, 1979) and forage samples collected according to Euclides (1992). The samples were collected when the animals were on the second day of occupation in both treatments. The hand plucking samples were also analyzed for total DM in an oven at 105ºC for 24 hours, total nitrogen (N; N×6.25 = crude protein; AOAC, 1990) and neutral and acid detergent fiber without amylase (Van Soest, 1967).

Statistical analysis

The results were analyzed with ANOVA and F-test at 5 % significance level. Differences between means were determined using the Tukey test for multiple comparisons , using the PROC MIXED model procedure, including the fixed effects of treatments, periods and the interaction treatment × period using, whereas animal group was a random effect SAS 9.4 software. Period was considered a repeated measure and best covariance structure chosen according to smallest Bayesian Information Criteria.

Results

The herbage mass (pregrazing) was well distributed over the treatments and periods of the trial without difference (P>0.05), however, there was interactions between treatments and periods (Table 2). The sward components from herbage mass was not different for treatments, had difference just for periods (Table 1), just leave blade had treatment periods interactions (Table 2). There were large fluctuations along periods for sward components; dead material was higher during cool season and leaves blade increased in the summer. The herbage allowance from green leaves blade had also large fluctuations, however not presenting difference between treatments and periods (Table 1).

Table 1 *Herbage mass, sward components and leaves allowance in a natural pasture rotationally grazed with two rest intervals (375 and 750 degree-day)*

Variables	Pregrazing	Postgrazing	Leaves Allowance	Leave Blade	Dead Material	Others	Stem
Treatments	Kg DM ha^{-1}			% Pregrazing			
375 DD	4406.7	3867.5	11.68	40.0	46.9	5.41	8.09
750 DD	4889.6	4400.2	7.72	40.5	48.0	3.39	8.69
SEM	178.5	176.8	0.919	0.937	1.01	0.422	0.286
Periods							
1	4391.8	2782.8^{D}	10.96	40.5^{ABCD}	50.0^{CD}	6.3^{AB}	5.08^{D}
2	4349.5	3307.6^{CD}	7.83	34.8^{CD}	54.7^{BC}	5.6^{AB}	4.86^{D}
3	5515.3	4835.1^{AB}	8.09	28.1^{D}	65.0^{A}	4.5^{AB}	3.07^{D}
4	5209.0	3811.0^{ABC}	6.43	27.8^{D}	66.3^{A}	2.5^{B}	3.17^{D}
5	4308.4	4052.8^{ABC}	7.78	30.9^{D}	62.6^{AB}	1.8^{B}	3.00^{D}
6	5121.8	4130.8^{ABCD}	9.17	37.7^{BCD}	57.7^{ABC}	1.6^{B}	4.17^{D}
7	4327.8	3589.7^{BCD}	8.01	41.7^{ABCD}	41.8^{DE}	5.0^{AB}	9.16^{C}
8	4164.9	3924.0^{ABCD}	8.01	42.1^{ABCD}	40.3^{DE}	5.7^{AB}	10.12^{BC}
9	5452.0	4616.9^{ABC}	15.63	37.7^{CD}	37.2^{E}	7.8^{A}	12.82^{ABC}
10	4845.0	4222.4A^{BCD}	13.2	51.8^{AB}	32.8^{E}	5.0^{AB}	12.94^{ABC}
11	4437.5	3661.6B^{CD}	12.72	53.1^{A}	30.9^{E}	3.8^{AB}	15.11^{A}
12	4084.2	5415.9^{A}	9.46	47.7^{ABC}	37.3^{E}	3.7^{AB}	13.59^{AB}
13	4218.3	5390.0^{A}	8.76	45.9^{ABC}	40.1^{DE}	3.4^{AB}	12.01^{ABC}
SEM	412.98	324.6	1.781	1.79	2.17	0.983	0.752
P - Values							
T	0.1959	0.1668	0.0931	0.7302	0.5182	0.0772	0.2823
P	0.1718	0.0001	0.0684	0.0001	0.0001	0.0101	0.0001
T×P	0.0186	0.0139	0.3957	0.0371	0.0505	0.3614	0.3318

Dry matter intake was similar amongst treatments but there was a difference amongst periods ($P < 0.05$) with different values in periods 1 and 3 (Table 3). Supplement and pasture intake did not differ among treatments or periods ($P>0.05$; (Table 3). Treatments did not affect the chemical composition, also not presenting difference among periods (Table 3), on average CP increased from period 1 to 4.

Table 2 *Treatment and periods interactions for forage production from nature pasture*

Periods	Pregrazing[1]		Postgrazing[1]		Leave blade[2]	
	375 DD	750 DD	375 DD	750 DD	375 DD	750 DD
1	3530^{B}	5253^{A}	2494	3071	40.5	36.4
2	4349	4578	3307	3307	34.8	32.6
3	4870	6160	4516	5153	28.1	26.4
4	5209	5209	3811	3811	27.8	27.8
5	3586	5031	3784	4321	30.9	34.1
6	4323	5921	3313^{B}	4948^{A}	37.7	39.3
7	5139	3516	3816	3663	41.6	48.1
8	4319	4010	4488	3359	42.1	48.2
9	6615^{A}	4289^{B}	4248	4985	37.7^{B}	51.3^{A}
10	3989^{B}	5700^{A}	3647	4796	51.8	47.3
11	4407	4467	3354	3968	53.1	47.2
12	3340	4827	4077^{B}	6754^{A}	47.7	42.9
13	3609	4952	5418	5361	45.9	42.7
SEM	825.95		649.25		3.5843	

Value within a row with different superscripts differ significantly at *$P<0.05$.*
[1]kg of dry matter ha^{-1}; [2]% of the pregrazing

Table 3 *Average values of dry matter intake (DMI, % BW), pasture intake (PI, kg day-1), supplement intake (SI, kg day-1), and chemical composition (% DM) of a native pasture from Pampa biome*

Item	Treatments		SEM	Periods				SEM	*P*- Value		
	375	750		21/06	06/09	11/12	02/04		T	P	T × P
DMI	2.23	2.24	0.095	1.96^{B}	2.09^{AB}	2.65^{A}	2.26^{AB}	0.1373	0.9652	0.0501	0.5333
PI	1.60	2.02	0.272	1.66	1.97	-	-	0.2245	0.3895	0.3072	0.9084
SI	1.70	1.84	0.203	1.73	1.81	-	-	0.1455	0.6850	0.2287	0.8566
CP	7.93	8.01	0.4032	7.55	7.58	8.15	8.61	0.4373	0.8968	0.3173	0.5802
NDF	72.64	73.29	0.8928	75.16	72.83	70.18	73.68	1.2217	0.6388	0.1477	0.8334
ADF	34.8	35.94	0.8626	38.16	34.52	33.76	35.03	1.2664	0.4728	0.1962	0.7223
DMDIS	41.34	43.59	1.1493	40.96	38.28	48.56	42.05	1.7252	0.2773	0.0498	0.5792

T = treatments; P = periods; T × P = treatments and periods interaction; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; DMDIS = dry matter degradability *in situ.*
^{A,B}Values within a row with different superscripts differ significantly at $P<0.05$.

There were treatment periods interaction (*P<0.05*) during warn season (Table 4) for animal production variables, with large fluctuation among periods.

The animal performance evaluations in this experiment were divided in two seasons: autumn, winter (period 1 to 5; Table 5) and spring, summer (period 6 to 13; Table 6). During cool season, the average daily gain was higher in the second period and lower in the third period, showed difference just for periods (Table 3), as also beef production. Both treatments maintained same mean stocking rate, stocking density and animal per day, however, the treatment 750 DD was better in cool season.

Table 4 *Interactions between treatments and periods for average daily gain (ADG), beef production (BP), mean stocking rate (MSR), stocking density (SD) and body weight final (BWF) during warn season from Pampa biome*

Variable	Treat	Periods								SEM
	(DD)	6	7	8	9	10	11	12	13	
ADG[1]	375	0.515	0.195	0.174	0.404	0.388	0.458^{A}	0.124	0.123^{A}	0.0068
	750	0.425	0.100	0.250	0.289	0.267	0.305^{B}	0.183	-0.096^{B}	
BF[2]	375	80.07	38.39	34.07	60.32	58.57	65.77	17.06	15.93^{A}	11.953
	750	59.5	25.5	59.25	40.5	37.5	42.66	24.63	-12.93^{B}	
MSR[2]	375	475.2	640.7^{B}	648.7^{B}	516.4	549.5	558.0	502.2	507.2	54.787
	750	448.6	786.4^{A}	796.6^{A}	493.9	516.2	540.4	542.0	533.3	
SD[2]	375	3327	4485^{B}	4540^{B}	3615	3847	3906	3516	3550	406.7
	750	3589	6292^{A}	6373^{A}	3951	4129	4323	4336	4266	
BWF[3]	375	174.2	179.6	184.5	195.8	206.7	219.2	223	224.5	9.955
	750	182.8	185.6	192.6	200.7	208.2	216.7	221.8	218	

Value within a column with different superscripts differ significantly at *P<0.05.*
[1]kg animal^{-1} day^{-1}; [2]kg ha^{-1}; [3]kg

Table 5 *Animal performance during autumn and winter in natural pasture from Pampa biome*

Variables	Body Weight Inicial[1]	Body WeightFinal[1]	Average Daily Gain[2]	Beef Production[3]	Mean Stocking Rate[3]	Stocking Density[3]	Animal per Day[4]
Treatments							
375 DD	151.5	159.8	0.056	46.11	430.9	3017.0	162.4
750 DD	149.6	170.9	0.143	121.71	452.9	3170.2	166.8
SEM	4.757	5.064	0.018	3.080	13.6732	95.763	2.752
Periods							
1	150.6^{B}	151.1^{D}	0.020^{B}	3.64^{B}	424.72^{C}	2973.0^{C}	157.3^{C}
2	151.1^{B}	159.9^{B}	0.275^{A}	49.7^{A}	447.97^{AB}	3135.6^{AB}	179.8^{A}
3	159.9^{A}	154.4^{C}	-0.186^{C}	-31.3^{C}	432.68^{C}	3028.6^{C}	168.5^{B}
4	154.4^{B}	159.2^{B}	0.180^{AB}	27.2^{AB}	441.57^{BC}	3091.0^{BC}	151.7^{C}
5	159.2^{A}	165.3^{A}	0.209^{A}	34.7^{A}	462.83^{A}	3239.8^{A}	165.7^{B}
SEM	3.506	3.604	0.037	5.769	10.3099	72.173	2.225
P - Values							
T	0.8907	0.6596	0.0835	0.0739	0.3747	0.3752	0.3710
P	0.0001	0.0001	0.0003	0.0001	0.0004	0.0004	0.0001
T×P	0.0834	0.0003	0.1368	0.1043	0.4730	0.4733	0.4325

T = treatments; P = periods; T × P = treatments and periods interaction; [1]kg of BW; [2]kg animal^{-1} day^{-1}; [3] kg ha^{-1}; [4]number of animals.
[A,B,C,D]Values within a column with different superscripts differ significantly at $P<0.05$.

Table 6 *Animal performance during spring and summer in nature pasture from Pampa biome*

Variables	Body Weight Inicial[1]	Body WeightFinal[1]	Average Daily Gain[2]	Beef Production[3]	Mean Stocking Rate[3]	Stocking Density[3]	Animal per Day[4]
Treatments							
375 DD	159.7	224.4	0.297	370.2	549.77	3848.3	157.9
750 DD	170.9	218.0	0.215	276.6	582.20	4657.5	162.7
SEM	5.352	6.851	0.023	4.678	28.4310	210.28	6.439
Periods							
6	165.3^{H}	178.5^{G}	0.470^{A}	69.78^{A}	461.93^{B}	3457.8^{B}	147.3^{B}
7	178.5^{G}	182.6^{F}	0.147^{CD}	31.93^{BC}	713.62^{A}	5388.5^{A}	219.7^{A}
8	182.6^{F}	188.5^{E}	0.211^{BC}	46.66^{ABC}	722.67^{A}	5456.8^{A}	216.2^{A}
9	188.5^{E}	198.2^{D}	0.346^{AB}	50.41^{AB}	505.15^{B}	3782.8^{B}	144.6^{B}
10	198.2^{D}	207.4^{C}	0.328^{AB}	48.03^{AB}	532.88^{B}	3988.2^{B}	144.6^{B}
11	207.4^{C}	218.0^{B}	0.381^{A}	54.21^{AB}	549.22^{B}	4114.6^{B}	142.0^{B}
12	218.0^{B}	222.4^{A}	0.153^{CD}	20.85^{CD}	522.15^{B}	3926.2^{B}	139.2^{B}
13	222.4^{A}	221.2^{AB}	0.013^{D}	1.5^{D}	520.28^{B}	3908.5^{B}	129.0^{B}
SEM	3.926	4.977	0.034	5.976	27.3938	203.3	6.906
P - Values							
T	0.6076	0.8294	0.1289	0.2190	0.5045	0.1127	0.6484
P	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
T×P	0.0749	0.0484	0.0259	0.0070	0.0035	0.0007	0.0055

T = treatments; P = periods; T × P = treatments and periods interaction; [1]kg of BW; [2]kg animal^{-1} day^{-1}; [3] kg ha^{-1}; [4]number of animals.
^{A,B,C,D}Values within a column with different superscripts differ significantly at *P<0.05.*

There was change of performance between treatments from cool season to warm season, 375 DD grazing intervals presenting a better performance during spring and summer, especially in average daily gain.

Discussion

Animal performance, expressed in terms of both ADG per animal and per unit area, varied markedly between periods of the trial. The variability in production is common, due there is lower C3 grasses contribution in the Pampa biome, this fluctuations are also normally in the northern savannas of Australia (Fordyce *et al*.,1993) and reflects the variation in the vegetal production. In our study, the positive ADG could be attributed to the nutritional attributes of herbage apparently selected by heifers, to the non-limiting herbage availability and to supplementation provided on cool season in the present study.

Generally, during autumn and winter in south Brazil grasslands there is large losses in animal production, which can reach 20 % of body weight of young heifers (Quintans *et al.,* 1994). Cattlemen's from Pampa biome complain about this natural resource due large fluctuation on animal production. Although it has been provided supplement, the herbage quality also helped to avoid loss weight, both grazing intervals (375 and 750 DD) had higher crude protein than normally was found in continuous grazing system on Pampa biome.

According to Ospina and Medeiros (2003) in a review of natural grassland quality, the mean value of crude protein and organic matter degradability are 6 %

and 45 % during the cool season. The herbage quality is not better due to high dead material percentage that reached 65 % of the total herbage mass during autumn and winter season (Table 1). These critical period for animal production in Pampa biome grasslands ranges from June to August.

The single use of herbage allowance adjustment did not avoid weight loss, even with value 3 to 4 times above the intake potential, considered non-limiting to feed intake of the animals (Sollenberger *et al.,* 2005). Using herbage allowance of 8 and 14 %of body weight under continuous grazing (Fontoura Júnior *et al.,*2007; Crancio *et al.,* 2006 and Soares *et al.,* 2005), reported weight loss in heifers and steers during the cool season.

According to Nabinger *et al.* (2009) an optimal animal performance (individual and per area) was found with an herbage allowance between 11.5 to 13.5% of body weight. In our trial, the herbage allowance from green leaves was smaller in the 750 DD, this could be because this grazing interval has more tussocks species (e.g. *Saccharum angustifolius*), that keep high dead material percentage along this experimental period and also since this management schedule started three years ago.

Pampa biome allows body weight gain around 0.5 kg per day during the warm season without hydric deficit (Nabinger *et al*., 2000), we found half this potential, however, the animal production per area was almost six time the mean of the Rio Grande do Sul state and higher than experimental procedures with continuous grazing (Soares *et al.,* 2005). The higher animal production of the present study could be attributed to the best nutritional value of herbage and to supplementation during cool season. Along the trial, only a period had weight loss, which allowed great beef production per area.

Rotational grazing system, with intervals of grazing followed by removal of animals to allow rest of the pasture from grazing and plant regrowth, are often used and have profound effects on the quantity and quality of pasture grown and that available to the grazing animal (Humphreys, 1991; Lemaire *et al.,* 2009).

The mean stocking rate and stocking density not decline the dry matter intake, although the high stocking rate could raise the competition for higher quality pasture components (O'Reagain *et al*., 2008).The herbage allowance was not limiting to feed intake, being 4 times more than the mean dry matter intake.

The level of production obtained from animals grazing vegetation depends on their ability to ingest a diet adequate to meet their nutrient requirements for maintenance, growth and reproduction (Gordon, 1995).

Probo *et al.* (2014) indicate that combining appropriate stocking levels and using rotational grazing system are management tools that have the potential to improve grazing distribution. Virgona *et al.* (2000), evaluating management strategies found that rotational grazing system provided greatest vegetation production and stocking rate.

Conclusion

This study has provided important data on the impact of different grazing strategies on animal performance and their potential to increase animal production, both treatments could be used as management tool. These results provide critical evidence to challenge the assumption that sustainable management is unprofitable.

The grazing management based in accumulated thermal sum (in degree-days) combined with supplementation during the cool season, could enable production systems to maintain profitable animal production while conserving natural ecosystem. Management practices that benefit natural resource require time and effort, and often capital, over and above input required to raise livestock.

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CAPÍTULO II

Natural grassland managed with two rest intervals: does it modifies beef heifers grazing behavior and feed intake?

Capítulo baseado nas normas para submissão de artigo científico da revista Archive Animal Nutrition

Natural grassland managed with two rest intervals: does it modifies beef heifers grazing behavior and feed intake?

Authors

Abstract: The objective of this study was to evaluate the effect of two rest intervals between grazing occupations in a rotational grazing; 375 and 750 DD (degree-days); based on the cumulative thermal sum necessary for leaf expansion duration of two grasses' functional groups on grazing behavior and feed intake variables. The experiment was conducted as a completely randomized block design, with two treatments, three replications and repeated measures over time with 8 to 18 months old beef heifers. Grazing behavior was assessed in seven occasions (June, July, September, November 2013 and February, March, April 2014). Grazing behavior was evaluated during 18 continuous hours (7 a.m. to 12 p.m.). Herbage intake was estimated using an external marker (Cr_2O_3) in four periods (June, September, December 2013 and March 2014). The green leaves mass was similar between treatments, with a mean of 40 % of the pregrazing mass (kg DM/ha). On average grazing time was 50 % of the time evaluated, bite rate was 38.7 bites/min. The number of daily meals was 6.5 with an average of 84 minutes each meal. The number of feeding stations visited per minute was 6.4. Dry matter intake (% BW) showed difference among periods, being on average 2.23 %. Chemical composition of apparently consumed forage was similar between treatments and both were similar considering heifers' grazing behavior and herbage intake.

Key Words: Pampa biome; thermal sums; grazing time; degree-days

Introduction

Natural grasslands are on decline on a global scale (Haddock; Good, 2012). Some types of agriculture (e.g., extensive grazing) are compatible with natural grassland functions but may not have as high an immediate economic return as other more intensive land uses. There is a need to reconcile individual economic needs with the needs of healthy functioning natural grasslands. One way to do this is to provide incentives that align long term, sustainable land management decisions with a stable and competitive economic return.

To improve the competitiveness with others land uses (e.g., crops, forestation) there is a need of management schedules of both forage and grazing animals as a key to successful grazing operations. A good goal is to develop a grazing system that uses properly managed and well-adapted forages while at the same time meeting the nutrient requirements of the animals. Various grazing management tools are available providing cattle farmers to more effectively use forage resources (e.g., forage allowance, adjustment of stocking rate) and they have been used to compete with alternative land uses.

Further research is needed for understanding the interrelationships of grazing behavior, dietary quality, forage intake, and vegetative (sward) characteristics. Methods of modifying behavior to control feed intake, improve efficiency, or to reduce stress could bring major contributions to the livestock industry. Thinking in this context, was proposed an experiment with two rest intervals between rotational grazing based in physiological traits of native grasses from Pampa biome. Our hypothesis is that this management tool could improve animal production and at the same time promote sustainable production and conservation of natural grasslands**.**

However, to make the most efficient use of the plant and animal resources is essential to improve our understanding of the foraging strategies of livestock, which use these ecosystems (Gordon, 1995). In this study, we use feeding behavior evaluations to indicate if the proposed management did not change animal behavior or natural grassland structure.

Material and Methods

Period, treatments and experimental area

The experiment was conducted from June 2013 to April 2014 in an area of natural grassland representative of the Pampa biome (IBGE, 2004). The experimental area is located at Federal University of Santa Maria (lat 29^0 43'S long 53^0 45'W), with 95 m above sea level. The climate site is subtropical humid climate (Cfa) according to Koppen classification. In the area there are two soil types: Typic Albaqualf on lowland areas and Rhodic Paleudalf on top and slope areas. During the trial, the mean maximum temperature was 23.4^{o}C and the mean minimum temperature was 17.1^{o}C, the mean precipitation during the trial was of 135.17 mm per month, October is the driest (53.6 mm) and November is the wettest (294.9 mm).

Treatments consisted of two different thermal sums, 375 and 750 degree-day (DD), determining the length of the rest intervals of paddocks between grazing events. The 375 DD is the interval necessary for the elongation of 2.5 leaves of *Axonopus affinis* and *Paspalum notatum*, which are prostrate C_4 grasses of the functional groups A and B (Quadros et al., 2006), with an average phyllochron of 150 DD (Eggers et al., 2004; Machado et al. 2013). The 750 DD represent the time for elongation of 2.2 leaves for tufted grasses from functional groups C and D (Quadros et al., 2006), as *Aristida laevis* and *Saccharum angustifolius,* with phyllochron of 333 DD (Machado et al., 2013).

The occupation time of each grazing cell was a function of rest time (between the grazing periods) according to the following formula:

$$\textit{Occupation (degree-days)} = \frac{\underline{\textit{Interval (DD)}}}{\textit{Nro. grazing cells -1 (cell in use)}}$$

Where DD is the treatment DD, 1 is the number of paddocks in use, and *Nro. grazing cells* is either 7 or 8 for the 375 and 750 DD treatments, respectively. For 375 DD, it ranges from 4 to 7 occupation days, with mean of 5.1 and for 750 DD, it ranges from 6 to 11 occupation days, with mean of 7.9 days. The climatic data was obtained from National Meteorological Institute (INMET), in the automatic meteorological station of Santa Maria, RS.

Both treatments were managed with constant stocking rate and variable herbage allowance during cool season (June to September). Along warm season (October to May), it was managed with variable stocking rate and for rate adjustments, it was used a variable number of “put-and-take” heifers, with the same age of the test-animals. Stocking rate (SR) was adjusted using the available proportion of leaves in the sward, so that the calculated SR could remove 70% of the leaf mass and keeping a residual mass of 1500 kg ha^{-1} under rotational grazing. A grazing cell (0.5 ha) was selected in each replicate (representative cell) for evaluations of quantity and quality variation in biomass and plant components contribution and where all pasture measurements were carried out.

The trial had seven evaluations of grazing behavior: June/13 (period 1), July/13 (period 2), September/13 (Period 3), November/13 (period 4), February/14 (period 5), March/14 (period 6) and April/14 (period 7). Feed intake was estimated at four periods: June/13 (period 1), September/13 (period 2) December/13 (period 3) and April/14 (period 4).

A completely randomized block design with two treatments and three replicates (six paddocks) were used. The experimental area had 23 ha divided into six paddocks (experimental units) randomly assigned to the two treatments with three replicates each. In treatment 375 DD, each replicate paddock was subdivided in seven grazing cells whereas in the 750 DD treatment the replicates were divided in eight cells for animal rotation. In total, 45 grazing cells with 0.5 ha each were used and all were provided with fresh water in drinking ponds.

Experimental animals, supplements and grazing management

A total of 30 beef heifers testers (average initial age of 8 months old) were used. All animals were Angus breed with a mean initial body weight of 151 ± 5.8 kg.

Heifers were blocked by body weight (6 groups with similar body weight). All heifers received daily supplementation of whole rice bran at 2:00 p.m. at a rate of 1.0 % of body weight, only during cool season (periods 1 and 2). Sanitary control was made when necessary with pour-on (Fluazuron or Fipronil) sprinkling shower (Amitraz), and vaccination as required.

Vegetation and animal measurements

Herbage mass (HM; kg of dry matter (DM) per ha) was measured using a direct comparison to standards calibrated with double-sampling technique (Haydock; Shaw, 1975), six samples were clipped at the ground level using 50 × 50 cm quadrats and 20 visual estimations were made in the representative cell for each replicate.

Removed biomass from clipped samples was weighted and divided into two subsamples. One was used to determine DM content, dried in a forced air oven at 55^{o}C for at least 72 hours and the another subsample was used to separate structural components. Manual separation of the structural components of the pasture was performed to obtain the percentage of green leaf lamina, pseudo stem (grass species), dead material and plant species other than grass (e.g. Cyperaceae, Asteraceae). Herbage allowance from green leaves blade (kg DM. 100 kg^{-1} of body weight. day^{-1}) was calculated using the mean leaf present in the HM (pregrazing) in each period, divided by the number of occupation days and divided by the instantaneous stocking rate (ISR) in body weight (kg/ha), multiplied by 100. The mean green leaves blade was calculated using the percentage of this component obtained by manual separation versus herbage mass of the cell available.

Instantaneous stocking rate (ISR), is the sum of all animals' body weight in an experimental group divided by the cell area. Mean stocking rate (MSR; kg ha^{-1} of body weight) was calculated as sum of all animal's body weight divided by paddock (repetition) area.

The herbage intake was evaluated on four occasions (June 12th to 21th, August 28th to September 6th, December 2th to 11th and March 24th to April 2th), using two animals by replicate, with Cr_2O_3 (chromium oxide). The period for adaptation and collection of feces samples comprised 10 consecutive days. Cr_2O_3 was provided together with 0.200 kg of whole rice bran, once a day (Kozloski et al., 2006). On the same occasion to avoid thermal discomfort for the animals in collection days, a polyethylene external marker was also provided, with different colors for each animal to identify its feces. The polyethylene external markers were made with plastic A4 paper of 0.3 mm thickness, using a manual machine binder (Excentrix) with 4 mm diameter. During ten consecutive days, animals were given 5g of Cr_2O_3, and in the last three days the fecal samples were collected directly in the grassland. The Cr_2O_3 supply was started considering the fecal collection when animals were moving into the representative paddocks. For collections, daily "sweeps" of feces on grassland were performed. If the polyethylene marker was found, samples were collected. The collected samples were dried until constant weight and after grinded on 1 mm.

Feces samples of 0.5g was weighed and incinerated in a muffle at 600ºC for Cr_2 determination. Afterwards, 5 ml Cr_2O_3 digestion acid solution was added, according to CzarnockI et al. (1961) and placed in a hot plate at 220ºC. After the change in sample color (green to yellow), the content was filtered and transferred to a 100 ml volumetric flask, completing the volume with distilled water to measure the Cr_2 concentration by atomic absorption spectrophotometry. The standard curve was prepared with 100 mg Cr_2O_3. Fecal production (FP) was estimated as follows: FP = supplied Cr_2O_3 (g/day) / feces [Cr_2] (g/kg DM). Then, the intake estimation was calculated as follows: Intake (g/day) = FP (g/day) / (1-degradability). *In situ* rumen degradability of herbage OM (ISRDOD) apparently consumed by animals was determined according to (Orskov; McDonald, 1979) and forage samples collected according to Euclides et al. (1992). The samples were collected when the animals were on the second day of occupation in both treatments. The hand plucking samples were also analyzed for total DM in an oven at 105ºC for 24 hours, total nitrogen (N; N×6.25 = crude protein; AOAC, 1990) and neutral and acid detergent fiber without amylase (Van Soest, 1967).

Statistical analysis

Data were analyzed with SAS 9.4 software for ANOVA and F-test at 5% significance level and 10% was considered as tendency. Differences between means were determined using the Tukey test for multiple comparisons , using the PROC MIXED model procedure, including the fixed effects of treatments, periods and treatment × period interaction, whereas animal group was a random effect. The animal behavior dataset was analyzed using the PROC GLIMMIX. Period was considered a repeated measure and best covariance structure chosen according to smallest Bayesian Information Criteria.

Results

No differences were found between treatments for vegetation evaluations, there was only significant among periods along of the experiment (Table 1). The pregrazing had treatment and periods interaction for period 2 (P=0.0243), period 3 (P=0.0137), period 6 (P=0.0117) and period 7 (P=0.0316), the 750 DD was higher. The leave blade component, increased from the third period, when started spring season, opposite behavior had dead material that decrease. The number and frequency of meals, bites rate, feeding time and steps showed were similar between treatments (Table 2). Considering the periods, only meal duration was significant, the last period was 50 minute higher than first period.

No differences were observed for chemical composition between treatments and periods (Table 3), however, the lower values were obtained during the first two periods. There were no differences for grazing time, rumination and resting between treatments, periods differ along the experiment (Figure 1). The lower grazing time was observed in the first period, where they spent about 40 % of the time making this activity. The resting time showed large fluctuation among periods, ranging from 8 to 27 %. Rumination time was lower in the second period, animals remained about 20 % of its time in rest.

Feed intake (% BW) was similar between treatments, there was difference among periods (Table 3). Pasture and supplement intake (kg animal^{-1} day^{-1}) were similar between treatments and periods (Table 3), supplement rate was about 50 % of the total dry matter intake.

Table 1. Herbage mass and allowance, sward components and mean stocking rate (MSR) of a nature pasture from Pampa biome

Variables	Pregrazing	Herbage Allowance	Leave Blade	Dead Material	Stem	MSR
Treatments	Kg DM ha^{-1}		% Pregrazing			Kg ha^{-1}
375 DD	4068.8	10.6	40.4	46.4	8.31	503.3
750 DD	4810.6	7.25	39.5	48.1	9.34	541.8
SEM	174.9	1.112	1.068	1.09	0.180	23.920
Periods						
1	4349.5^{B}	7.83^{AB}	34.8^{B}	54.7^{A}	4.86^{D}	447.9^{BC}
2	5515.3^{A}	8.09^{AB}	28.1^{B}	65.0^{A}	3.07^{D}	432.8^{C}
3	4308.4^{B}	7.78^{B}	30.9^{B}	62.6^{A}	3.00^{D}	462.8^{BC}
4	4164.9^{B}	8.01^{B}	42.1^{A}	40.3^{B}	10.12^{C}	549.2^{B}
5	4437.5^{AB}	12.72^{A}	53.1^{A}	30.9^{B}	15.11^{A}	722.6^{A}
6	4084.2^{B}	9.46^{AB}	47.7^{A}	37.3^{B}	13.59^{AB}	522.2^{BC}
7	4218.3^{B}	8.76^{AB}	45.9^{A}	40.1^{B}	12.01^{BC}	520.2^{BC}
SEM	250.47	1.781	1.898	2.19	0.478	25.209
P - Values						
T	0.0956	0.1631	0.6164	0.3585	0.0562	0.3735
P	0.0101	0.0057	0.0001	0.0001	0.0001	0.0001
T×P	0.0496	0.0517	0.3381	0.3354	0.0927	0.0360

Notes: value within a column with different superscripts differ significantly at $P<0.05$.

Table 2. Animal behavior of beef heifers grazing in nature pasture

Treat	Meal Duration Min/meal	Meal Frequency Meals/day	Bites Rate Bites/min	Feeding Time Feeds/min	Steps Feeds Steps/feeds
375 DD	81.8	6.8	39.9	6.7	1.5
750 DD	86.0	6.2	37.5	6.2	1.7
SEM	2.95	0.224	2.49	0.424	0.088
Periods					
1	61.6^{C}	5.8	31.5	5.8	1.5
2	80.8^{ABC}	6.6	34.6	4.8	1.5
3	72.6^{BC}	6.5	40.5	7.3	1.8
4	91.3^{ABC}	7.6	38.1	6.0	1.5
5	69.6^{BC}	6.5	40.5	6.6	1.5
6	99.6^{AB}	6.5	40.5	7.7	1.5
7	111.5^{A}	5.9	45.3	6.8	1.7
SEM	6.95	0.431	2.85	0.727	0.137
P – Values					
T	0.422	0.212	0.555	0.464	0.289
P	0.001	0.155	0.067	0.165	0.903
T×P	0.328	0.199	0.087	0.292	0.775

Notes: value within a column with different superscripts differ significantly at $P<0.05$.

Table 3. Average values feed intake (FI, % BW), pasture intake (PI), supplement intake (SI) of beef heifers and chemical composition (% DM), crude protein (CP), Acid and neutral detergent fiber (ADF and NDF), dry matter degradability *in situ* (DMDIS) of a native pasture from Pampa biome

Item	Treatments		SEM	Periods				SEM	*P*- Value		
	375	750		21/06	06/09	11/12	02/04		T	P	T × P
FI	2.23	2.24	0.095	1.96^{B}	2.09^{AB}	2.65^{A}	2.26^{AB}	0.1373	0.9652	0.0501	0.5333
PI	1.60	2.02	0.272	1.66	1.97	-	-	0.2245	0.3895	0.3072	0.9084
SI	1.70	1.84	0.203	1.73	1.81	-	-	0.1455	0.6850	0.2287	0.8566
------------Chemical composition------------											
CP	7.93	8.01	0.4032	7.55	7.58	8.15	8.61	0.4373	0.8968	0.3173	0.5802
NDF	72.64	73.29	0.8928	75.16	72.83	70.18	73.68	1.2217	0.6388	0.1477	0.8334
ADF	34.8	35.94	0.8626	38.16	34.52	33.76	35.03	1.2664	0.4728	0.1962	0.7223
DMDIS	41.34	43.59	1.1493	40.96	38.28	48.56	42.05	1.7252	0.2773	0.0498	0.5792

Notes: value within a row with different superscripts differ significantly at $P<0.05$.

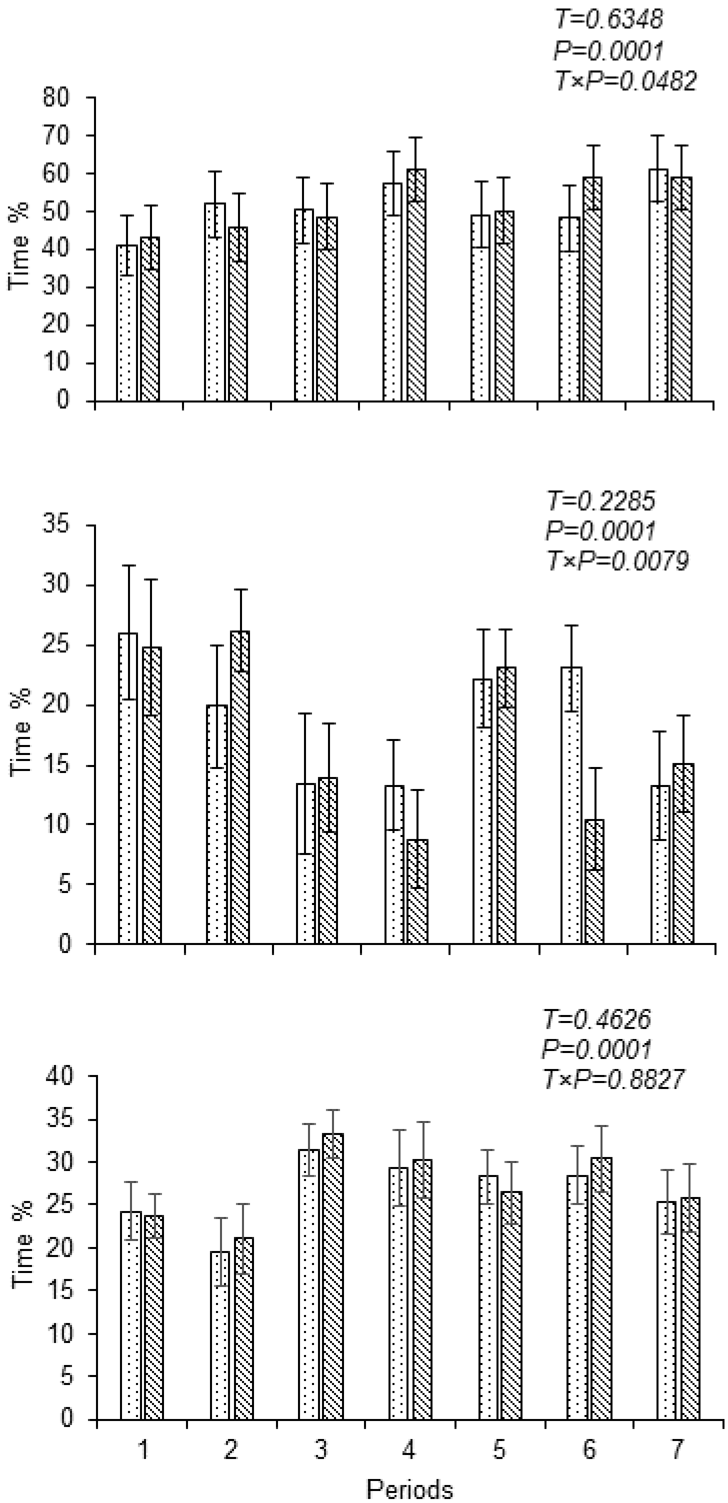

Figure 1. Proportion of time spent by beef heifers (a) grazing, (b) resting and (c) ruminating. Light downward column is 375 DD and light downward diagonal is 750 DD. *P*= value, T= treatment, P= period and T×P= treatment and period interaction.

Discussion

The aim of this study was to evaluate the beef cattle heifer's feeding behavior when the natural grassland was managed with two rest intervals under rotational grazing. In our study, herbage mass (pregrazing) was high because we calculated the biomass including also tussocks, differently than others authors that use just intertussock area (Da Trintade et al., 2015). Although without difference for herbage mass, the tussocks number is higher in the 750 DD, due to this treatment be predominantly composed of *Saccharum angustifolium* and *Aristida laevis* tussocks.

The herbage allowance did no limit dry matter intake, with values of three to four times the intake potential, considered non-limiting to animals' feed intake (Sollenberger et al., 2005). However, concerning grazing behaviour, results indicated that differently from what occurs in cultivated pastures, herbage allowance or herbage mass were not enough to explain the observed grazing time. (Pinto et al., 2007). The sward structure was not evaluated in this article; therefore, this approach is not discussed here. Nevertheless, we may affirm that sward structure in both treatments is not limiting animal behavior.

According to Carvalho & Moraes (2005), in swards with non-limiting herbage allowance, animals present a higher number of meals and, in each, a shorter time, promptly filling their rumen. Our results are confirming their assertion, the meal duration (min per meal) was lower than results found by Barbieri et al. (2015) and Mezzalira et al. (2012). already Meal frequency (meals per day) were similar to the results recorded by Barbieri et al. (2015) in the same site under rotational grazing and higher than Mezzalira et al. (2012) under continuous grazing with 12 % of herbage allowance.

The bites rate (bites per min), feeding time (feeds per min) and steps feeds (steps per min) were similar to the results found to Barbieri et al. (2015). The average sward conditions that promoted a high daily forage intake, as well as a high nutrient intake rate, by cattle grazing natural grassland of the Pampa Biome occurred around 12.1% BW of forage allowance, characterized by a biomass between 1 820 and 2 280 kg DM per ha and between 11.5 and 13.4 cm of height, with tussock levels that did not exceed 30% (Da Trindade et al., 2015). In our trial the herbage allowance was almost 12%, however, this allowance was just from green leaves different of the authors above that used all biomass. Thus, is possible to say that sward structure did not limit heifer's feed intake. Favorable herbage allowances are frequently associated with high values of herbage intake per bite and lower rates of biting (Hodgson, 1982), probably because ruminants prefer living (growing) to dead (senescent) material, younger to older material, and leaf to stem (Arnold, 1981).

On average, the grazing time was of 50 % in both treatments. In a so considered good management schedule (12 % herbage allowance) Da Trindade et al.(2012) found, during warm season, 43 % and 39 during cool season, however, they evaluated just daylight animal behavior. Barbieri et al., (2015) found 43 % of grazing time in the same area during continuous 24 hours of visual observation. The ruminating and resting time were lower in our trial compared to Barbieri et al., (2015) data, however, we used lower mean stocking rate in both treatments, which could allow higher selectivity and consequently increase grazing time.

According to Da Trindade et al. (2012) in herbage mass from Pampa biome below 1620 kg DM ha and 10.1 cm of height, animals had decreased DMI, which cannot be compensated by increasing daily grazing time. This not occurred in our trial, vegetation data enabled comfortable conditions for feeding behavior.

Variations in vegetative (sward) characteristics can have a profound effect on grazing behavior, According to Da Trindade et al. (2014), the same herbage allowance may result in different sward structures, but some of them could not be favorable for feeding intake and then the animal uses compensatory strategies to the ingestive process (Laca, 2008).

The dry matter intake increased among periods probably as a consequence of variation in forage quality, mainly the percentage of green leaves. If low palatability was responsible by the reduction on feed intake, then eating rate, meal duration and DMI should have been reduced from the beginning to the end of the trial, which did not occur in our trial. Considering that instantaneous feed intake multiplied by grazing time correspond to daily dry matter intake, this was also similar between treatments, as there was no difference for feeding behavior evaluations . Our results were higher than Barbieri et al., (2015) that found 2.04 % BW under rotational grazing during warm season. Da Trindade et al., (2015) in natural grassland of Pampa biome grazed continuously with different forage allowance levels, found our same value, in the forage allowance of 8%. However, they used as external indicator the C_{32}-Alkane.

Conclusions

Both treatments are similar considering evaluated ingestive behavior variables and estimated feed intake. Therefore, both treatments can be to use as alternative management tool.

The grazing interval of 750 DD is more conservative, by considering tussock like grasses and not limiting feed intake.

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DISCUSSÃO

A realização deste trabalho possibilitou diagnosticar o grande desafio que é manejar ambientes pastoris de alta complexidade florística, portanto, é necessário que ferramentas de manejo de ordem prática sejam geradas para auxiliar técnicos e/ou produtores na tomada de decisões, e consequentemente aumentarem os índices de produção animal.

O intervalo de descanso entre pastoreios baseado na duração de elongação foliar, que é dependente principalmente da temperatura, desempenha papel central na morfogênese, influenciando diretamente o índice de área foliar, ou seja, a estrutura da pastagem, e pode ser uma ferramenta que aliada a outras práticas de manejo, como o pastoreio rotativo possibilitam a construção de ambientes pastoris adequados a produção de herbívoros.

Os resultados obtidos no capítulo 1 demonstram que é possível elevar a produção animal, principalmente o ganho por área, desta forma as ferramentas de manejo utilizadas podem ser uma alternativa viável para a utilização das pastagens naturais. Os resultados de produção animal poderiam ter sidos superiores, infelizmente, nos períodos 7 e 8 os desempenhos foram prejudicados em função da contaminação por coccidiose do género Eimeria, após a profilaxia os ganhos de peso retornaram ao esperado.

Embora os resultados tenham sido satisfatórios é necessário encontrar a verdadeira aptidão das pastagens naturais, talvez trabalhar com uma categoria animal de menor exigência nutricional possa promover melhores índices de produção animal.

No segundo capítulo os resultados de comportamento ingestivo e consumo de matéria seca, demonstram que os tratamentos não limitaram a resposta do animal em pastejo, ou seja, a maneira na qual a pastagem foi disponibilizada aos animais não limitou o processo de colheita do pasto, portanto, a disposição estrutural das plantas não foi alterada pelos tratamentos.

Embora escritos em capítulos separados podemos afirmar que o desempenho dos animais não foi limitado pelo consumo de matéria seca.

Com a finalização deste trabalho podemos afirmar que é possível maximizar a utilização das pastagens naturais com adequadas ferramentas de manejo, assim, com informações consistentes, podemos argumentar sobre a preservação deste ambiente de extrema importância social, econômica e cultural para o estado do Rio Grande do Sul.

CONCLUSÃO

Os tratamentos de 375 GD e 750 GD em pastoreio rotativo mostraram ser uma alternativa promissora de manejo para as pastagens naturais, permitindo elevadas taxas de lotação.

Para obtenção de níveis mais elevados de produção animal, a utilização de categorias com maior idade, principalmente durante a estação fria deverá ser considerada em trabalhos futuros.

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APÊNDICE A – MATRIZ DE DADOS DO TRATAMENTO 375 GRAUS-DIA

TRAT	REP	PER	OFLF	CA	GMD	PCI	PCF	GA
375	1	1	13.13	444.43	0.111	147.60	150.70	17.71
375	2	1	16.81	375.29	-0.150	154.30	150.10	-21.60
375	3	1	10.57	445.29	0.239	152.80	159.50	38.29
375	1	2	8.32	457.86	0.216	150.70	157.60	39.43
375	2	2	9.95	399.14	0.216	150.10	157.00	35.49
375	3	2	13.37	464.71	0.216	159.50	166.40	39.43
375	1	3	7.22	435.00	-0.333	157.60	147.60	-57.14
375	2	3	10.51	382.00	-0.183	157.00	151.50	-28.29
375	3	3	11.91	439.71	-0.350	166.40	155.90	-60.00
375	1	4	6.70	441.71	0.130	147.60	151.10	20.00
375	2	4	10.54	395.29	0.248	151.50	158.20	34.46
375	3	4	9.96	442.14	0.081	155.90	158.10	12.57
375	1	5	7.82	439.43	0.034	151.10	152.10	5.71
375	2	5	8.26	453.57	0.221	158.20	164.60	36.57
375	3	5	10.58	449.43	0.155	158.10	162.60	25.71
375	1	6	3.16	440.71	0.450	152.10	164.70	64.80
375	2	6	11.57	498.00	0.571	164.60	180.60	91.43
375	3	6	13.57	487.00	0.525	162.60	177.30	84.00
375	1	7	7.98	460.29	0.225	164.70	171.00	32.40
375	2	7	18.58	751.29	0.171	180.60	185.40	40.39
375	3	7	8.56	710.71	0.189	177.30	182.60	42.38
375	1	8	10.03	470.57	0.193	171.00	176.40	27.77
375	2	8	11.69	760.86	0.157	185.40	189.80	36.73
375	3	8	9.30	714.57	0.171	182.60	187.40	37.71
375	1	9	10.26	499.86	0.511	176.40	190.70	73.54
375	2	9	39.26	499.86	0.286	189.80	197.80	41.14
375	3	9	12.16	549.43	0.414	187.40	199.00	66.29
375	1	10	11.32	525.57	0.364	190.70	200.90	52.46
375	2	10	15.61	526.71	0.296	197.80	206.10	42.69
375	3	10	12.00	596.43	0.504	199.00	213.10	80.57
375	1	11	15.12	548.29	0.418	200.90	212.60	60.17
375	2	11	21.73	493.14	0.487	206.10	219.00	62.29
375	3	11	11.95	632.57	0.468	213.10	226.20	74.86
375	1	12	10.19	450.00	0.186	212.60	217.80	24.27
375	2	12	10.38	461.71	0.114	219.00	223.00	14.93
375	3	12	7.75	595.14	0.071	226.20	228.20	12.00
375	1	13	12.21	456.00	0.107	217.80	220.80	12.00
375	2	13	8.06	454.29	0.063	223.00	218.75	7.00
375	3	13	7.44	611.43	0.200	228.20	233.80	28.80

Continuação

TRAT	PER	REP	LF	COLMO	M.M	MFE	MFS	MLF
375	1	1	38.14	4.81	46.47	3882.03	2854.73	1480.71
375	1	2	41.31	7.34	46.84	3875.56	2619.59	1601.16
375	1	3	42.17	5.45	38.42	2832.69	2009.08	1194.48
375	2	1	34.56	6.15	49.70	3601.23	2717.72	1244.48
375	2	2	33.37	3.25	61.17	3888.16	2244.22	1297.62
375	2	3	36.52	5.20	53.24	5559.30	4960.95	2030.13
375	3	1	30.80	2.20	59.49	3332.84	3255.82	1026.46
375	3	2	22.91	3.31	70.78	5724.15	5093.14	1311.28
375	3	3	30.79	2.16	56.73	5553.29	5199.91	1710.05
375	4	1	27.76	1.68	66.56	4031.41	2325.47	1119.00
375	4	2	28.22	4.31	66.13	5579.16	4169.36	1574.61
375	4	3	27.68	3.53	66.36	6016.49	4938.44	1665.38
375	5	1	28.52	3.47	64.24	3375.75	2792.58	962.78
375	5	2	31.96	3.20	63.39	3282.16	4895.21	1048.85
375	5	3	32.47	2.24	63.83	4099.69	3665.93	1331.03
375	6	1	38.50	2.43	57.17	1949.21	2037.25	365.45
375	6	2	43.19	5.10	50.94	4502.49	4872.03	1512.82
375	6	3	31.44	3.92	62.14	6516.14	3030.59	1734.54
375	7	1	45.72	4.82	40.94	2749.65	2112.29	799.86
375	7	2	43.80	9.64	42.27	7941.78	6393.40	3040.71
375	7	3	35.56	8.19	55.40	4726.78	2942.38	1325.42
375	8	1	35.07	3.94	58.86	3826.88	3345.65	991.45
375	8	2	50.90	11.56	32.69	4670.04	4081.97	1868.12
375	8	3	40.33	12.91	37.72	4460.20	6036.98	1395.38
375	9	1	40.31	9.87	41.97	3671.06	2775.02	1076.71
375	9	2	45.36	20.06	30.60	10086.53	5027.11	4121.40
375	9	3	27.59	9.69	53.05	6086.26	4943.08	1403.06
375	10	1	52.96	9.95	27.81	3447.09	3571.06	1296.04
375	10	2	52.58	18.19	26.50	4404.63	4964.40	1790.14
375	10	3	50.03	12.40	35.81	4115.78	2408.44	1558.97
375	11	1	56.01	8.00	29.13	4004.84	3250.39	1682.95
375	11	2	50.39	15.75	31.15	5316.25	4062.28	2175.17
375	11	3	52.90	15.94	27.07	3901.79	2750.81	1535.00
375	12	1	48.51	14.42	29.99	3232.25	3000.57	1082.89
375	12	2	54.67	14.73	29.04	3070.95	5483.47	1132.29
375	12	3	40.08	13.20	39.64	3719.50	3748.72	1090.07
375	13	1	48.37	5.92	44.02	4021.75	3828.41	1461.75
375	13	2	43.73	15.57	33.48	3198.01	6327.07	961.19
375	13	3	45.81	11.39	38.23	3607.44	6099.94	1194.43

APÊNDICE B – MATRIZ DE DADOS DO TRATAMENTO 750 GRAUS-DIA

TRAT	REP	PER	OFLF	CA	GMD	PCI	PCF	GA
750	1	1	8.59	424.71	-0.068	159.70	157.80	-10.86
750	2	1	8.01	437.57	0.050	143.70	145.10	8.00
750	3	1	8.67	421.00	-0.061	145.50	143.80	-9.71
750	1	2	4.22	451.29	0.400	157.80	170.60	73.14
750	2	2	4.31	460.86	0.284	145.10	154.20	52.00
750	3	2	6.85	453.86	0.322	143.80	154.10	58.86
750	1	3	5.43	438.57	-0.147	170.60	166.20	-25.14
750	2	3	6.38	455.86	-0.030	154.20	153.30	-5.14
750	3	3	7.12	444.86	-0.073	154.10	151.90	-12.57
750	1	4	2.97	450.57	0.204	166.20	171.70	31.43
750	2	4	4.04	466.43	0.274	153.30	160.70	42.29
750	3	4	4.40	453.29	0.144	151.90	155.80	22.29
750	1	5	4.32	465.57	0.241	171.70	178.70	40.00
750	2	5	8.26	494.14	0.317	160.70	169.90	52.57
750	3	5	7.46	474.86	0.290	155.80	164.20	48.00
750	1	6	9.24	439.00	0.504	178.70	192.80	70.50
750	2	6	7.73	467.88	0.461	169.90	182.80	64.50
750	3	6	9.77	439.00	0.311	164.20	172.90	43.50
750	1	7	2.95	712.50	0.018	192.80	193.30	4.01
750	2	7	4.33	961.13	0.193	182.80	188.20	53.38
750	3	7	5.69	685.75	0.089	172.90	175.40	19.07
750	1	8	3.30	716.88	0.118	193.30	196.60	26.12
750	2	8	6.28	976.00	0.336	188.20	197.60	90.61
750	3	8	7.50	697.00	0.293	175.40	183.60	61.03
750	1	9	10.82	474.38	0.404	196.60	207.90	56.50
750	2	9	9.69	524.00	0.264	197.60	205.00	37.00
750	3	9	11.61	483.25	0.200	183.60	189.20	28.00
750	1	10	11.55	490.00	0.175	207.90	212.80	24.50
750	2	10	13.07	549.75	0.314	205.00	213.80	44.00
750	3	10	15.70	508.75	0.314	189.20	198.00	44.00
750	1	11	9.64	503.00	0.129	212.80	216.40	18.00
750	2	11	7.30	580.50	0.364	213.80	224.00	51.00
750	3	11	10.63	537.75	0.421	198.00	209.80	59.00
750	1	12	9.31	488.00	0.221	216.40	222.60	27.90
750	2	12	5.36	598.50	0.264	224.00	231.40	37.00
750	3	12	13.81	539.63	0.064	209.80	211.60	9.00
750	1	13	8.14	478.25	-0.121	222.60	219.20	-15.30
750	2	13	4.65	592.25	-0.018	231.40	227.60	-2.50
750	3	13	12.07	529.38	-0.150	211.60	207.40	-21.00

Continuação

TRAT	PER	REP	LF	COLMO	M.M	MFE	MFA	MLF
750	1	1	41.95	4.36	51.35	4565.35	3713.32	1915.02
750	1	2	30.97	4.23	61.11	5941.69	2742.57	1840.00
750	1	3	36.46	4.29	56.23	5253.52	2757.55	1915.29
750	2	1	34.56	6.15	49.70	3601.23	2717.72	1244.48
750	2	2	33.37	3.25	61.17	3888.16	2244.22	1297.62
750	2	3	36.52	5.20	53.24	5559.30	4960.95	2030.13
750	3	1	26.45	3.04	68.95	5201.59	3048.24	1376.08
750	3	2	25.00	3.05	70.22	6712.72	6421.41	1678.35
750	3	3	27.87	4.67	64.32	6567.64	5992.06	1830.32
750	4	1	27.76	1.68	66.56	4031.41	2325.47	1119.00
750	4	2	28.22	4.31	66.13	5579.16	4169.36	1574.61
750	4	3	27.68	3.53	66.36	6016.49	4938.44	1665.38
750	5	1	24.34	2.46	71.94	4478.12	3837.14	1089.86
750	5	2	38.60	3.25	55.97	5739.17	5300.21	2215.10
750	5	3	39.40	3.40	56.26	4875.92	3825.73	1921.25
750	6	1	38.05	5.50	63.71	6117.16	4941.59	1947.06
750	6	2	43.42	5.21	50.39	5000.00	4555.43	1736.91
750	6	3	36.45	2.89	62.22	6646.23	5347.92	2057.88
750	7	1	46.48	7.40	41.97	2628.78	3147.33	757.07
750	7	2	49.17	11.84	34.31	4048.30	3237.43	1498.79
750	7	3	48.93	13.12	36.12	3871.41	3705.64	1404.98
750	8	1	46.48	7.40	41.97	2626.93	3147.33	756.21
750	8	2	49.17	11.84	34.31	4990.48	3237.58	1962.04
750	8	3	48.99	13.10	36.09	4415.16	3694.73	1673.13
750	9	1	51.20	12.60	35.07	4208.34	4506.71	1642.74
750	9	2	51.87	10.48	31.67	4132.26	4067.15	1624.64
750	9	3	50.88	14.23	30.76	4527.86	6382.87	1794.87
750	10	1	43.68	9.97	39.38	5147.12	5419.76	1811.43
750	10	2	52.31	16.30	29.69	5396.59	4519.40	2299.86
750	10	3	45.97	10.83	37.71	6558.91	4451.60	2555.24
750	11	1	43.32	12.52	41.12	4708.61	2780.74	1606.71
750	11	2	48.09	18.64	29.81	3922.21	4392.29	1405.29
750	11	3	50.25	19.82	26.96	4771.50	4733.47	1895.26
750	12	1	40.79	10.03	47.33	4690.84	5980.14	1505.50
750	12	2	39.65	16.20	41.59	3683.97	8073.26	1064.19
750	12	3	48.37	12.96	36.04	6108.05	6209.35	2470.74
750	13	1	40.79	10.03	47.33	4690.84	4380.44	1505.50
750	13	2	39.65	16.20	41.59	3683.97	6232.78	1064.19
750	13	3	48.37	12.96	36.04	6108.05	5471.41	2470.74

APÊNDICE C – MATRIZ DE DADOS DAS AVALIAÇÕES DE CONSUMO

Treat	Per	Group	Rep	Body weight	DMI	Intake % BW
375	1	1	1	145.8	2.58	1.79
375	1	2	2	152.8	3.02	1.99
375	1	3	3	203.5	3.72	1.84
750	1	4	1	183.0	3.73	2.04
750	1	5	2	204.0	3.92	1.92
750	1	6	3	152.8	3.41	2.21
375	2	1	1	144.3	2.67	1.85
375	2	2	2	181.0	4.00	2.21
375	2	3	3	197.0	3.89	1.98
750	2	4	1	189.3	4.72	2.53
750	2	5	2	216.5	4.00	1.85
750	2	6	3	159.8	3.45	2.13
375	3	1	1	168.0	5.90	3.53
375	3	2	2	218.5	5.48	2.53
375	3	3	3	217.5	5.21	2.43
750	3	4	1	206.5	5.10	2.46
750	3	5	2	248.0	5.54	2.25
750	3	6	3	178.0	4.84	2.72
375	4	1	1	202.5	5.03	2.48
375	4	2	2	274.5	6.14	2.25
375	4	3	3	274.5	5.40	1.99
750	4	4	1	239.5	5.97	2.50
750	4	5	2	292.5	5.69	1.96
750	4	6	3	210.5	4.99	2.38

APÊNDICE D – MATRIZ DE DADOS DAS AVALIAÇÕES DE COMPORTAMENTO INGESTIVO

TREAT	PERIOD	REP	BLOCK	Others	Rest	Grazing	Ruminate	Total
375	1	1	1	50	112	210	138	510
375	1	2	2	28	177	196	114	515
375	1	3	3	55	114	220	121	510
750	1	1	1	45	164	196	105	510
750	1	2	2	35	91	262	122	510
750	1	3	3	45	129	200	136	510
375	2	1	1	50	100	239	111	500
375	2	2	2	47	94	274	85	500
375	2	3	3	35	104	264	97	500
750	2	1	1	35	113	254	98	500
750	2	2	2	30	125	247	103	505
750	2	3	3	40	159	189	117	505
375	3	1	1	20	106	235	149	510
375	3	2	2	25	44	258	188	515
375	3	3	3	20	64	280	146	510
750	3	1	1	20	76	272	147	515
750	3	2	2	20	63	239	193	515
750	3	3	3	25	76	239	175	515
375	4	1	1	0	69	287	149	505
375	4	2	2	2	72	277	154	505
375	4	3	3	0	61	303	141	505
750	4	1	1	0	41	306	158	505
750	4	2	2	0	52	307	156	515
750	4	3	3	0	43	322	150	515
375	5	1	1	5	117	235	143	500
375	5	2	2	0	89	201	114	404
375	5	3	3	4	104	248	139	495
750	5	1	1	1	121	238	140	500
750	5	2	2	3	124	238	135	500
750	5	3	3	0	104	281	125	510
375	6	1	1	0	156	219	130	505
375	6	2	2	0	89	267	149	505
375	6	3	3	0	109	244	152	505
750	6	1	1	0	76	287	152	515
750	6	2	2	0	40	318	157	515
750	6	3	3	0	49	305	161	515
375	7	1	1	0	95	257	153	505
375	7	2	2	0	50	335	120	505
375	7	3	3	0	60	333	112	505

Continuação

TREAT	PERIOD	REP	BLOCK	Others	Rest	Grazing	Ruminate	Total
750	7	1	1	0	64	318	128	510
750	7	2	2	0	71	322	122	515
750	7	3	3	0	100	266	149	515

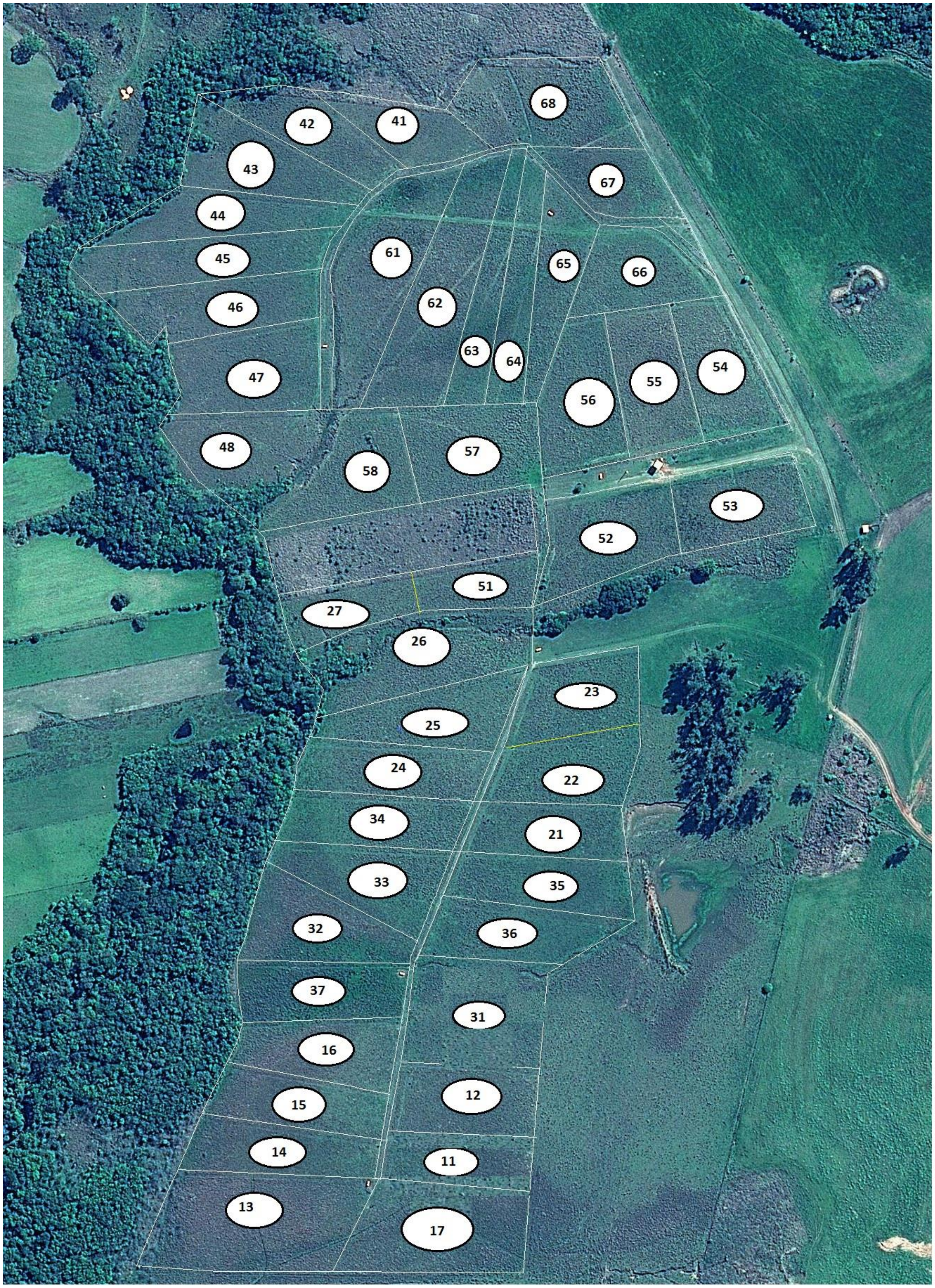
APÊNDICE E – MATRIZ DE DADOS DAS AVALIAÇÕES DE COMPORTAMENTO INGESTIVO

TREAT	PER	REP	BLOCK	FEEDS/MIN	STEPS/EST	BITES/MIN	MEAL/DAY	MEAL DURATION
375	1	1	1	7.0	1.5	25.2	6	70
375	1	2	2	5.5	1.5	37.6	5.6	48
375	1	3	3	5.7	1.8	42.5	6.8	71
750	1	1	1	7.1	1.2	32.1	5	47
750	1	2	2	5.0	1.9	25.3	6.2	67
750	1	3	3	4.6	1.6	26.2	5.6	67
375	2	1	1	4.6	1.4	31.0	5	85
375	2	2	2	4.5	1.3	28.3	8.4	78
375	2	3	3	4.3	1.7	34.5	5.4	85
750	2	1	1	6.6	1.4	45.4	7.8	94
750	2	2	2	5.2	1.9	30.1	6	75
750	2	3	3	3.8	1.8	38.5	7.4	68
375	3	1	1	6.1	1.7	36.5	4.8	69
375	3	2	2	10.6	.	37.6	5.2	96
375	3	3	3	9.2	1.5	36.3	8.2	74
750	3	1	1	7.7	1.3	55.6	7	70
750	3	2	2	6.9	2.0	41.0	5.4	61
750	3	3	3	3.5	2.7	35.9	8.2	66
375	4	1	1	6.6	1.3	25.8	9.25	115
375	4	2	2	6.4	1.8	42.4	6	68
375	4	3	3	6.9	1.4	49.7	8.6	87
750	4	1	1	6.5	1.3	39.0	7.8	102
750	4	2	2	5.6	1.8	36.9	6.6	75
750	4	3	3	4.1	1.9	34.8	7.8	101
375	5	1	1	7.8	1.4	36.6	8.2	76
375	5	2	2	6.2	1.5	42.2	6.4	54
375	5	3	3	8.0	1.6	53.7	6.8	59
750	5	1	1	7.6	1.2	29.0	5.4	64
750	5	2	2	4.3	1.7	47.1	6.2	74
750	5	3	3	5.9	2.0	34.6	6.2	91
375	6	1	1	7.4	1.5	36.9	7.6	78
375	6	2	2	6.4	1.4	45.9	7	89
375	6	3	3	5.8	2.0	42.1	8.4	90
750	6	1	1	14.7	1.2	33.7	5.4	120
750	6	2	2	6.5	1.9	43.3	4.6	94
750	6	3	3	5.7	1.5	41.3	6	127
375	7	1	1	9.7	1.7	51.0	5.6	103
375	7	2	2	7.1	1.3	51.3	7.2	78

Continuação

TREAT	PER	REP	BLOCK	FEEDS/MIN	STEPS/EST	BITES/MIN	MEAL/DAY	MEAL DURATION
375	7	3	3	5.4	1.5	52.2	6.4	145
750	7	1	1	5.5	2.2	35.7	6.2	122
750	7	2	2	6.5	1.3	45.3	4.8	119
750	7	3	3	6.6	2.2	36.4	5.2	102

ANEXO A – CROQUI DA ÁREA EXPERIMENTAL



ANEXO B - MANUAL RÁPIDO PARA PREPARAÇÃO DE ARTIGOS DA REVISTA ANIMAL JOURNAL

Manuscript title [Arial 12 bold, style 'ANM a paper title']

F. A. Author [1,a] [Arial 12 regular, style 'ANM superscript'], S.-B. Author [2,b], T. Author [3] and F. Author Jr [1,2] [Arial 12 regular, style 'ANM author name']

[1] *Department, Institution, Place (e.g. Street, Building, PO Box, City, State), Country [Arial 12 italic, style 'ANM authors address']*

[2] *Department, Institution, Place (e.g. Street, Building, PO Box, City, State),* Country

[3] *Department, Institution, Place (e.g. Street, Building, PO Box, City, State), Country*

[a, b] *Present address: Department, Institution, Place (e.g. Street, Building, PO Box, City, State), Country (For any author whose present address differs from that at which the work was done)*

Corresponding author: First name Last/Family name. Email: firstname.familyname@company.com [Arial 12 regular, style 'ANM author address']

Short title: Should not exceed 50 characters [Arial 12 regular, style 'ANM main text']

Abstract [Arial 12 bold, style 'ANM heading 1']

The abstract should be in a single paragraph and should not exceed 400 words. There should be no references to tables, figures or bibliography [Arial 12 regular, style 'ANM main text'].

Keywords [Arial 12 bold, style 'ANM heading 1']: Keyword 1, Keyword 2, Keyword 3, Keyword 4, Keyword 5 [Arial 12 regular, style 'ANM main text']

Implications [Arial 12 bold, style 'ANM heading 1']

Authors must write maximum 100 words explaining the implications of their work. Implications explain the expected importance or economic, environmental and/or social impact. This must be in simple English suitable for non science readers. The Implications will be peer-reviewed [Arial 12 regular, style 'ANM main text'].

Introduction [Arial 12 bold, style 'ANM heading 1']

Text [Arial 12 regular, style 'ANM main text'].

Material and methods [Arial 12 bold, style 'ANM heading 1']

Text [Arial 12 regular, style 'ANM main text'].

Subheading [Arial 12 italic, style 'ANM heading 2']

Text [Arial 12 regular, style 'ANM main text'].

Sub-subheading [Arial 12 italic, style 'ANM heading 3']. Text [Arial 12 regular, style 'ANM main text'].

Results [Arial 12 bold, style 'ANM heading 1']

Text [Arial 12 regular, style 'ANM main text'].

Subheading [Arial 12 italic, style 'ANM heading 2']

Text [Arial 12 regular, style 'ANM main text'].

Sub-subheading [Arial 12 italic, style 'ANM heading 3']. Text [Arial 12 regular, style 'ANM main text'].

Discussion [Arial 12 bold, style 'ANM heading 1']

Text [Arial 12 regular, style 'ANM main text']. The discussion section may be combined with the results section, but it is discouraged.

Subheading [Arial 12 italic, style 'ANM heading 2']

Text [Arial 12 regular, style 'ANM main text'].

Sub-subheading [Arial 12 italic, style 'ANM heading 3']. Text [Arial 12 regular, style 'ANM main text'].

Acknowledgements [Arial 12 bold, style 'ANM heading 1']

Text [Arial 12 regular, style 'ANM main text'].

ANEXO C – MANUAL RÁPIDO PARA PREPARAÇÃO DE ARTIGOS DA REVISTA ARCHIVE ANIMAL NUTRITION

Advice to authors on preparing a manuscript

Please follow any specific Instructions for Authors provided by the Editor of the journal, which are available on the journal pages at www.tandfonline.com. Please also see our guidance on putting your article together, defining authorship and anonymizing your article for peer review.

We recommend that you use our templates to prepare your article, but if you prefer not to use templates this guide will help you prepare your article for review.

If your article is accepted for publication, the manuscript will be copyedited and typeset in the correct style for the journal.

Font: Times New Roman, 12 point, double-line spaced. Use margins of at least 2.5 cm (or 1 inch). Guidance on how to insert special characters, accents and diacritics is available here.

Title: Use bold for your article title, with an initial capital letter for any proper nouns.

Abstract: Indicate the abstract paragraph with a heading or by reducing the font size. Check whether the journal requires a structured abstract or graphical abstract by reading the Instructions for Authors. The Instructions for Authors may also give word limits for your abstract. Advice on writing abstracts is available here.

Keywords: Please provide keywords to help readers find your article. If the Instructions for Authors do not give a number of keywords to provide, please give five or six. Advice on selecting suitable keywords is available here.

Headings: Please indicate the level of the section headings in your article:

 First-level headings (e.g. Introduction, Conclusion) should be in bold, with an initial capital letter for any proper nouns.

 Second-level headings should be in bold italics, with an initial capital letter for any proper nouns.

 Third-level headings should be in italics, with an initial capital letter for any proper nouns.

 Fourth-level headings should be in bold italics, at the beginning of a paragraph. The text follows immediately after a full stop (full point) or other punctuation mark.

 Fifth-level headings should be in italics, at the beginning of a paragraph. The text follows immediately after a full stop (full point) or other punctuation mark.

Tables and figures: Indicate in the text where the tables and figures should appear, for example by inserting [Table 1 near here]. The actual tables should be supplied either at the end of the text or in a separate file. The actual figures should be supplied as separate files. The journal Editor's preference will be detailed in the Instructions for Authors or in the guidance on the submission system. Ensure you have permission to use any tables or figures you are reproducing from another source.

- Advice on obtaining permission for third party material is available here.
- Advice on preparation of artwork is available here.
- Advice on tables is available here.

Running heads and **received dates** are not required when submitting a manuscript for review; they will be added during the production process.

Spelling and punctuation: Each journal will have a preference for spelling and punctuation, which is detailed in the Instructions for Authors. Please ensure whichever spelling and punctuation style you use is applied consistently.

If you have any queries…

If you need further advice, please contact us at authorqueries@tandf.co.uk giving the full title of the journal to which you are planning to submit, or see our Author Services website.